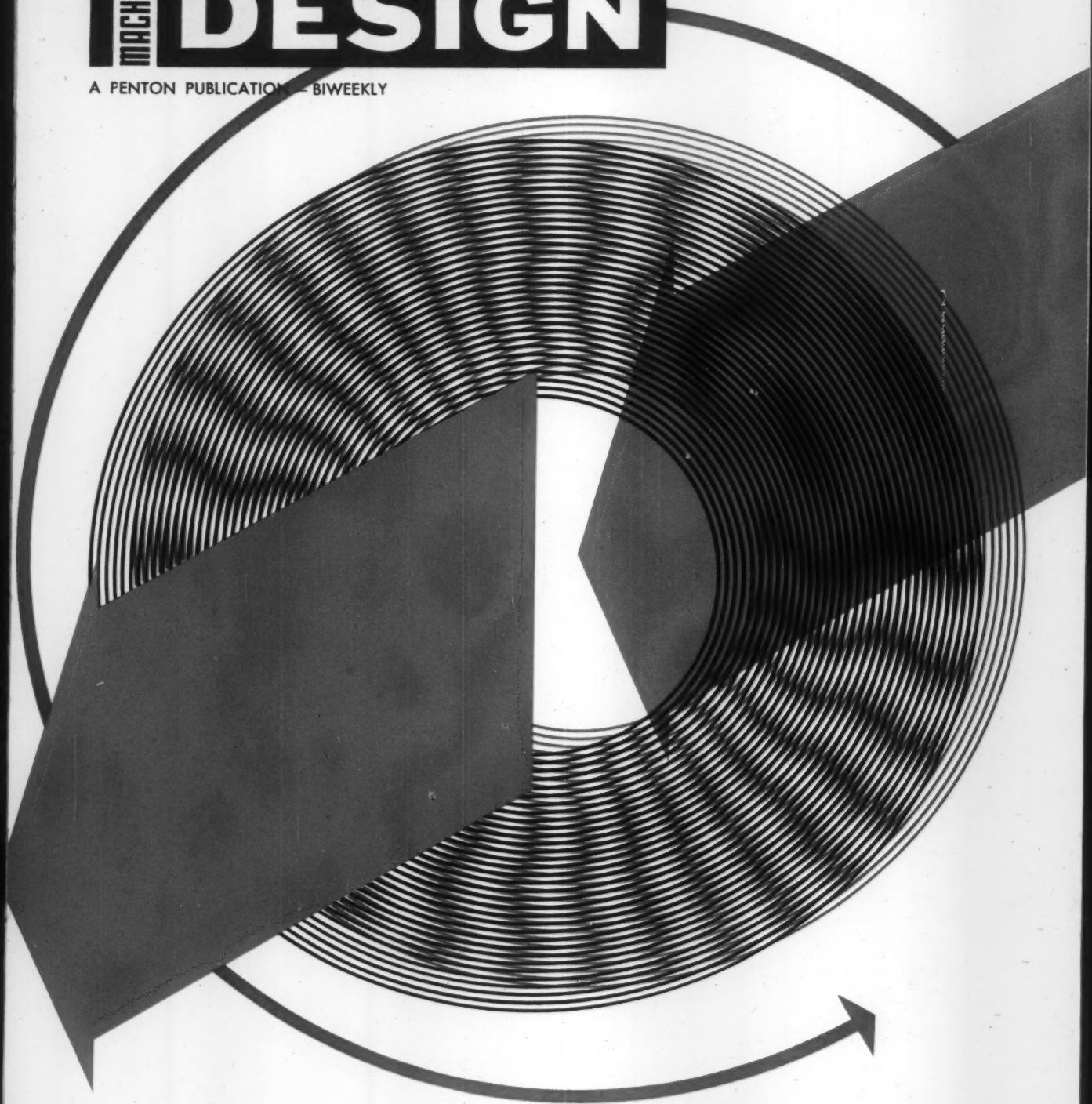
NOVEMBER 13, 1958

MACHINE DESIGN

A FENTON PUBLICATION — BIWEEKLY



Friction-Clutch Transmissions

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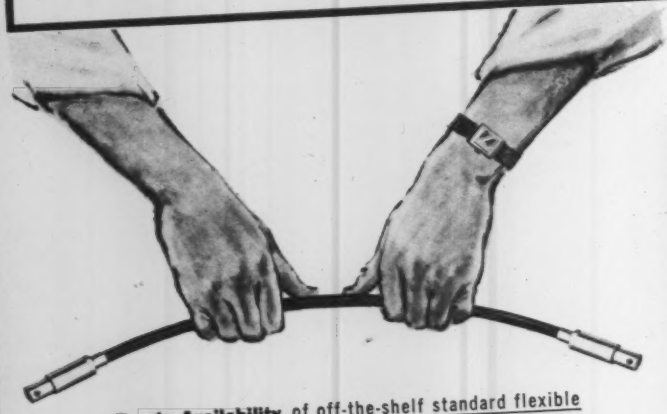
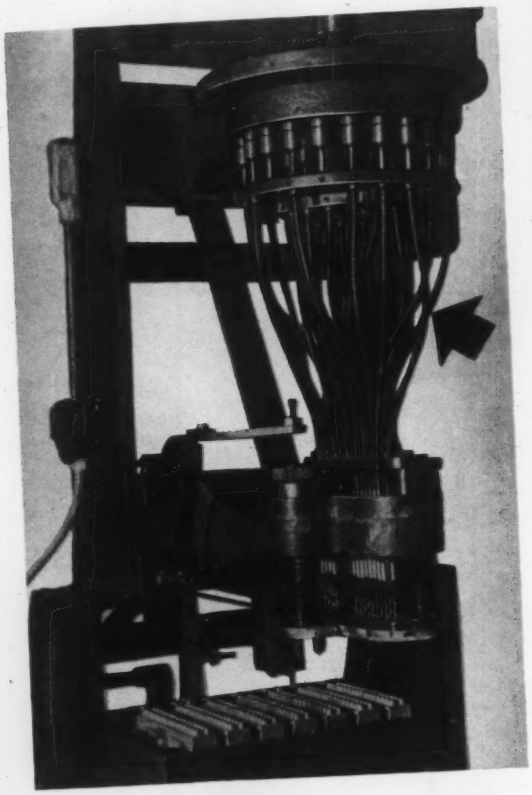
ACKWORTH

DRIVE AND CONTROL IDEAS FOR ENGINEERS

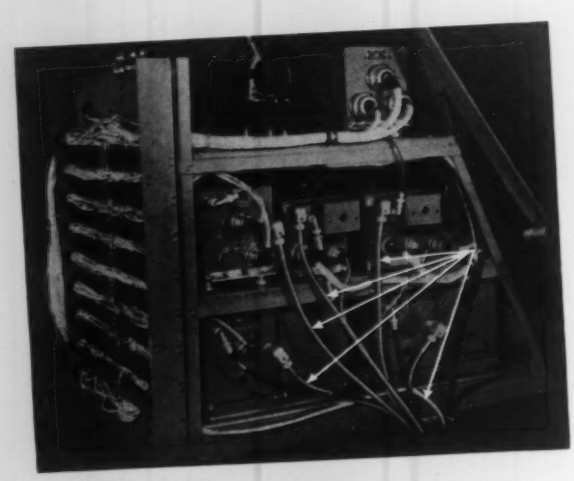
Tips on better designing with ***FLEXIBLE SHAFTS***



Ready Availability of off-the-shelf standard flexible shafts is a convenience and economy offered engineers by S.S.WHITE. Complete, ready to install, they are ideal for testing experimental designs or for small production runs on remote controls or power drives. Designed for ready attachment to your engaging parts, they come in three-foot lengths in three different diameters. Longer lengths available on request. Write for Bulletin 5801.



Drilling Patterns can be readily changed in this flexible shaft multiple spindle drill press. There are 38 spindles in this particular machine, any or all of which may be used simultaneously and readily regrouped as desired. The small diameter of the S.S.WHITE flexible drive shafts also permits drills to be set on closer center than on ordinary multiple spindle drilling equipment.



Reliability of Control is essential in the communication and navigation equipment of a small executive type airplane. The equipment, shown here, is operated by the pilot through a remote turning unit connected to the equipment by five S.S.WHITE remote control flexible shafts. Since it is designed for complete instrument flying on the airways, dependability is essential.

S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

S.S.WHITE INDUSTRIAL DIVISION
10 East 40th Street, New York 16, New York
Western Office: 1839 West Pico Blvd. Los Angeles 6, Calif.

S.S.WHITE offers engineering service and a complete selection of flexible shaft sizes and types to meet specialized design requirements. For cost-saving, design-simplifying ideas in flexible drive, coupling and control shafts, write for Bulletin 5601. (Dept. 4)

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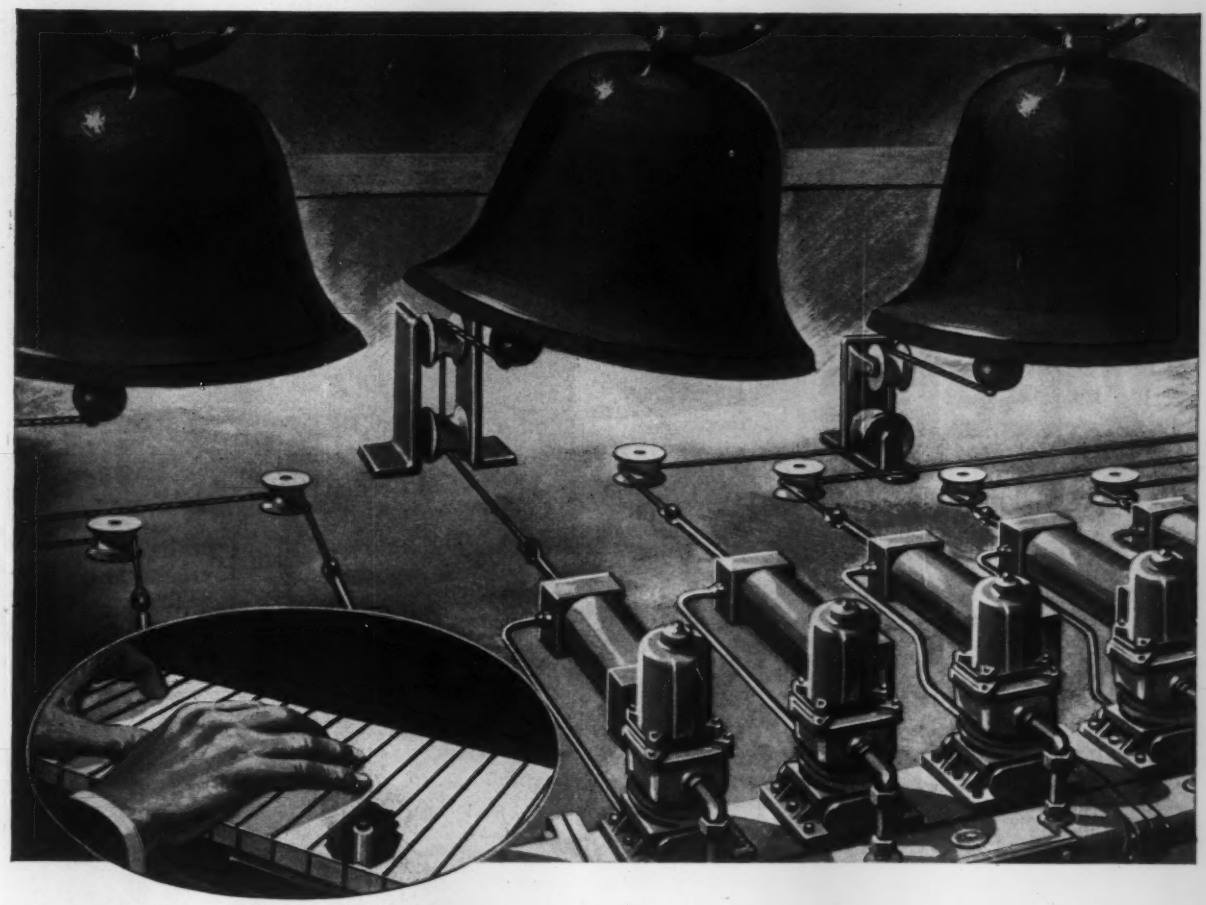


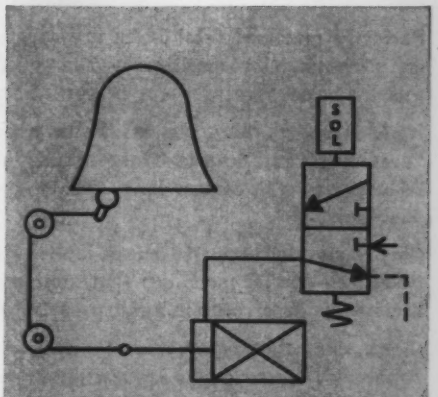
What? Air Power Rings the Bells!

Air powered clappers for the bell tower may be strictly fiction, but . . .

Can you imagine a keyboard that's a set of electrical switches. They operate a set of solenoid valves which in turn advance and retract cylinders. The cylinders, of course, pull the clapper cords. Shows that anything can happen when an air-minded engineer gets in the spirit of the season. But while this is just a flight of the imagination that you aren't likely to see installed in a carillon soon, you might very well want to take advantage of the underlying idea in some of your *plant operations*. Here is the idea:

Just one operator can control hundreds of operations by using solenoid valves.

And these solenoid valves, you'll notice, are manifolded. The manifolding saves piping, space, etc., just as has been possible for years with Ross valves that are operated manually, by air, cams, etc. Incidentally, you won't find this manifold in our catalog . . . it is one of the many refinements and variations of the standard Ross line that make it so flexible. To keep fully aware of the developments continually being made to increase the flexibility of the Ross line, keep in close touch with your local Ross Valve Engineer.



SEQUENCE OF OPERATION

Every time solenoid is energized, bell clapper is pulled against bell.

ROSS OPERATING VALVE CO. 109 East Golden Gate • Detroit 3, Michigan

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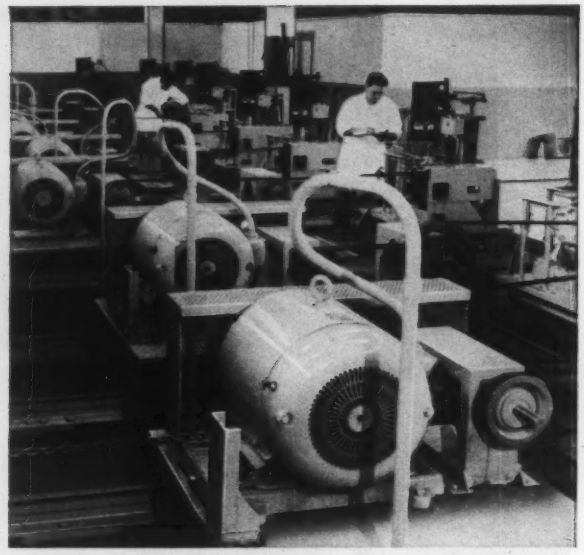
Why V-Belts with the Green Seal meet every test



Nearly one-third of all electric power used at the Goodyear V-Belt plant goes into testing, checking and development operations. These giant dynamometers, for example, test larger belts in all speed ranges and with various pulley diameters—with belt loads from zero to 100 h.p. The effects of reverse bending, various placements of idlers and high or low tension are also checked.

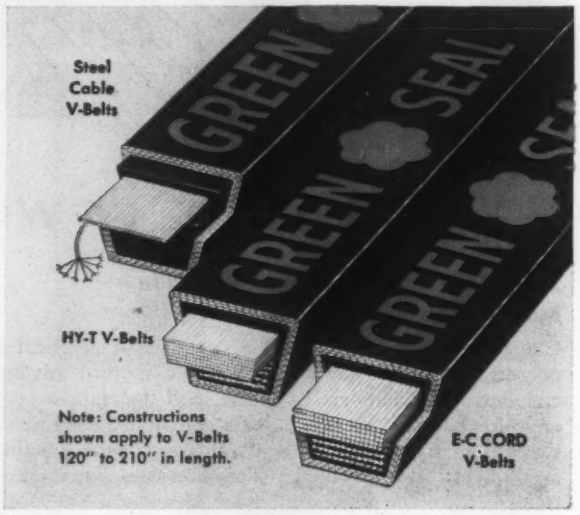
Dimensional stability! Belts are even test-run in closed, high-temperature ovens—to verify that their 3-T (Triple-Tempered) construction remains dimensionally stable under extreme operating conditions.

Perfectly matched sets! Belts are carefully measured on ultra-precision machines – then carefully coded to guard against "loafers" – or belts that overwork.

High strength, low stretch! Belts are subjected to "breaking point" tensile-strength tests in the Goodyear laboratories – to insure long, trouble-free service on your drives.

Maximum resistance to shock-loads! Belts are "tortured" on special machines that simulate the severest service – your protection against early belt failure.

Clean, smooth-running operation! Special nondusting rubber cover compounds are continually tested for friction balance – to give you freedom from sticking or grabbing in the grooves.



To pay off in—

Maximum trouble-free horsepower hours at minimum cost. That makes it a real gamble to settle for anything less than V-Belts with the Green Seal. See your Goodyear Distributor – or write Goodyear, Industrial Products Division, Lincoln 2, Nebraska, or Akron 16, Ohio.

DIMENSIONALLY STABLE V-BELTS with the GREEN SEAL by

GOODYEAR

60th ANNIVERSARY

THE GREATEST NAME IN RUBBER

Green Seal, E-C Cord, Hy-T –T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

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Front Cover: Two whirling friction discs transmit power in this cover by George Farnsworth. A new series by Z. Janio on friction-clutch transmissions starts on Page 132.

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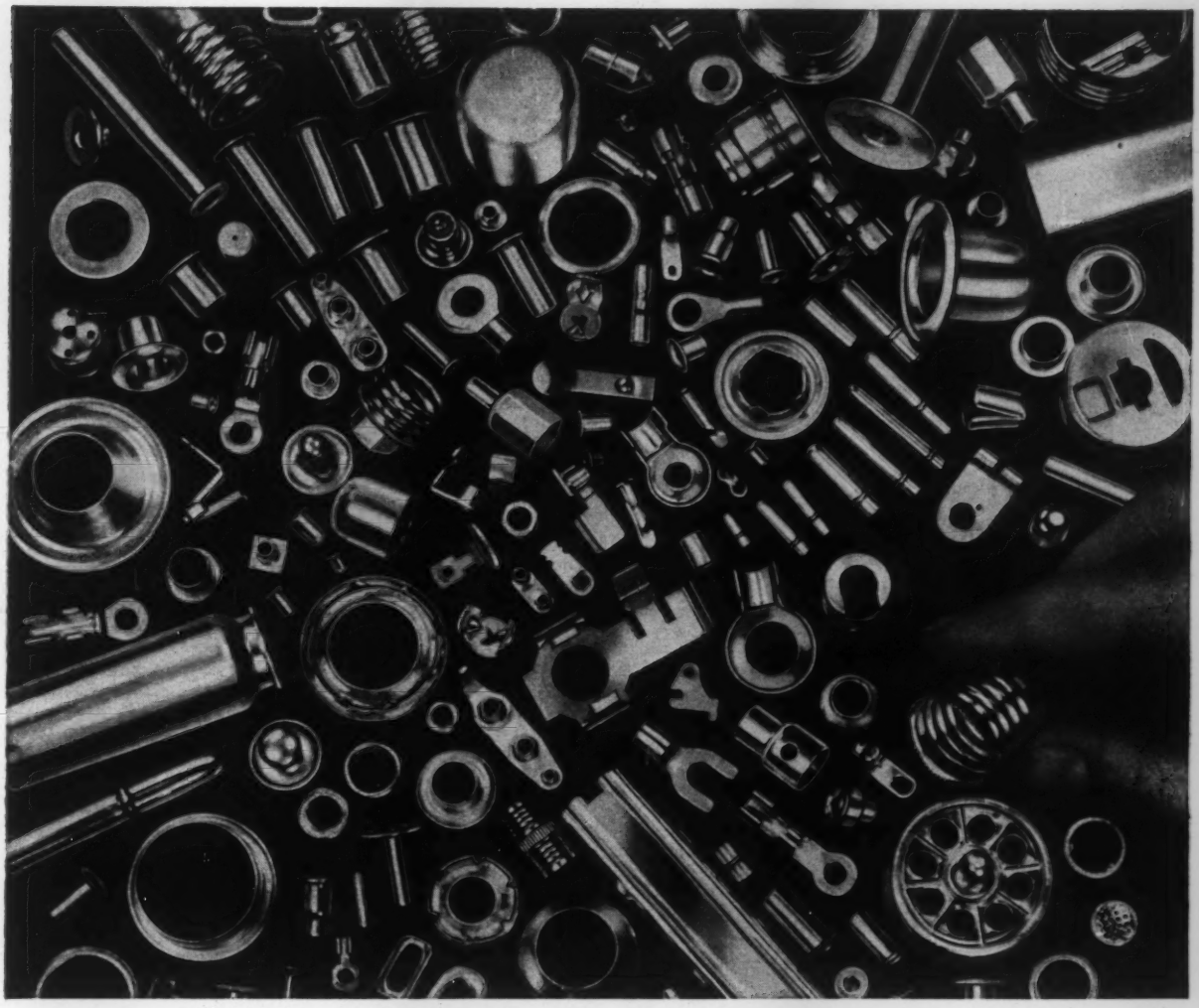

All of these parts were designed to serve a specific function—at a lower cost. Some are made by customer-owned tools.

Pick a part! any part . . . any metal

Then ask us for an eye-opening quotation

These are only a few of the thousands of multiple-plunger and progressive-tool press products we supply to every branch of industry—from simple eyelets to precision electronic components.

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Send your inquiry to: The American Brass Company, Fabricated Metal Goods Division, Waterbury 20-A, Connecticut.

5852 Rev.

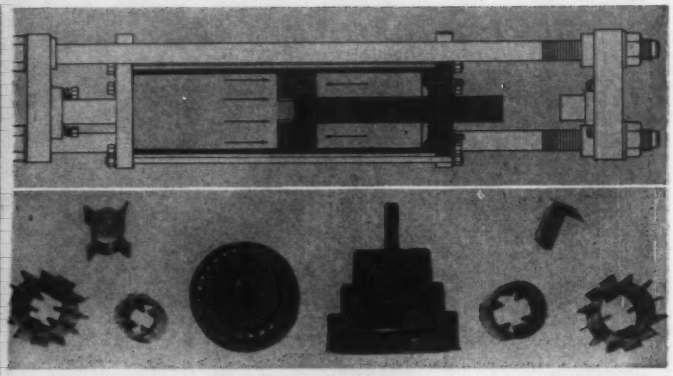
NEW CATALOG: Send for Publication BG-5, "Anaconda Fabricated Metal Products." It suggests design possibilities and production economies available with multiple-plunger and progressive-tool press products. Information on deep drawn and stamped parts is also included.

ANACONDA®

Multiple-Plunger Press Products

ENGINEERING NEWS

135-mph Ram Blasts Out Metal Parts



High-velocity metal forming has moved out of the laboratory with the introduction of Dynapack, a production machine which delivers a precisely controlled 40,000 ft-lb wallop to a metal slug. Growing out of a five-year study of high-velocity forming with explosives, the device uses compressed nitrogen to give its ram velocities in excess of 200 fps in a 12-in. stroke. Accessories not shown in the top sketch counteract the tendency for cylinder pressure to drop as the piston moves out. Dynapack gives the designer of small, formed parts complete freedom to specify hot or cold no-draft forgings, small-radius bends, and radical change in cross-sections. Dynapack was developed by Convair Div., General Dynamics Corp., San Diego, Calif.

Unruly English Tamed for Man-Machine Talk

Unambiguous Language Being Readied by Patent Office

The first 150 terms of a new language that machines will understand is ready for publication by the U. S. Patent Office. The P.O. wants to talk to machines in order to enlist them in its search work —the job of finding out what has already been patented or published, and therefore can't be patented again.

Wanted: Plain Talk

Called Ruly English, as distinguished from the everyday unruly English we speak and write, the new tongue contains words that are not necessarily pronounceable. They are roots modified by prefixes and suffixes. One root, for example, is **resilrig,** whose meaning combines resilience and rigidity.

Machines have to be instructed in very unambiguous language; they remember but they don't think. If two things are involved, they are likely to reverse the order, putting the cart before the horse and the cheese outside the sandwich. The matter of relationships being so important, plain-talk specialists began by looking at existing prepositions.

Simon M. Newman, engineer in charge of the linguistic phase of the work, found that the prepositions of Unruly English were a mass of multiple meanings. Was the cart *behind* the horse in *place*, in *time*, in *progress*, or as a *cause*? He logged thirteen meanings for *through*, thirty-two for *of* and forty-three for *to*.

As an experiment, Mr. Newman devised twenty-five Ruly prepositions (actually relationship terms). They were unlovely to the eye and ear but would be beautiful on magnetic tape.

One, for example, is **howby.** In machine talk, howby displaces *as* in "to limp as the result of a fall," *by* in "to take by force," *from* in "to gain a polish from wear," *in* in "to argue in a circle," and so on down to *with* in "to kill with kindness."

Information Please

Besides devising the machine language, the Patent Office research and development staff has two other major jobs—to find the best way of committing some seven million U.S. and foreign patents and other sources to electronic memories, and to find the best way of getting the information out again. When they succeed with all three, an examiner should be able to ask the ma-

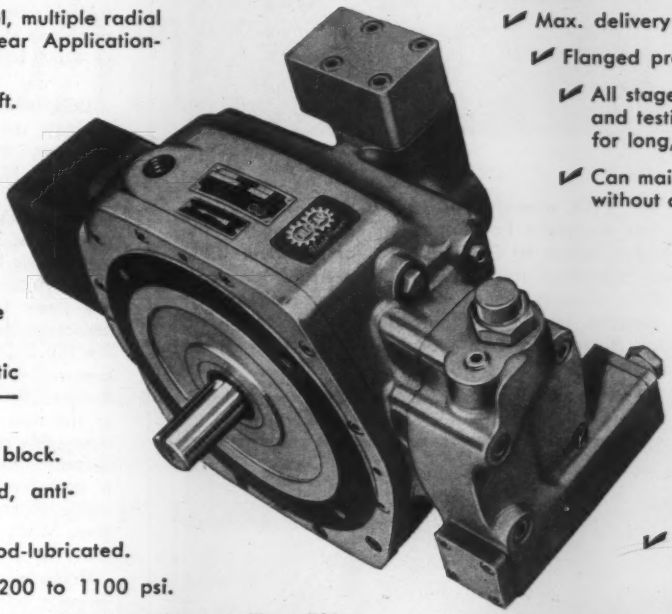
... Fluid Power news

NEW RADIAL PISTON VARIABLE DISPLACEMENT PUMP

OILGEAR ANNOUNCES NEW "Power-Saver" PUMPS

New Type "ANP" Pumps Generate Only Needed Power — Boost System Efficiency

- ✔ Simple, one piece, alloy steel, multiple radial rolling pistons — an Oilgear Application-Proved, exclusive design.
- ✔ One-piece cylinder and shaft.
- ✔ Balanced flat valve (port plate) and separate wear plate to assure a controlled oil film between working surfaces . . . high volumetric efficiency over entire pressure range.
- ✔ Integral, adjustable volume control.
- ✔ Integral, adjustable, automatic pressure unloading control — 200 to 1100 psi.
- ✔ Precision, bearing-type slide block.
- ✔ Large, conservatively loaded, anti-friction bearings.
- ✔ Completely pressure and flood-lubricated.
- ✔ Working pressure range — 200 to 1100 psi.



- ✔ Max. delivery to 3100 cipm (13½ gpm).
- ✔ Flanged pressure and suction ports.
- ✔ All stages of manufacturing, assembly and testing under strict quality control for long, dependable service life.
- ✔ Can maintain a static load indefinitely without overload or excessive heating.
- ✔ Adjust pump volume to suit optimum ram speed — no excess oil to "wire-draw," blow past a relief valve or generate heat.
- ✔ Adjust pressure to maximum force needed. When this preset pressure is reached, control automatically reduces pump to slip stroke to save power — reduce heat.
- ✔ Available clockwise or counterclockwise rotation at no extra cost.

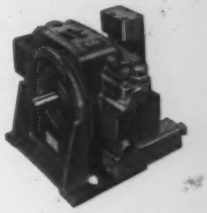
- ✔ Built for continuous, full-load service on pushing, pulling, lifting, lowering applications . . . on machines requiring positive, static loads over intermittent or long periods . . . for automatic charging of accumulator systems . . . for repetitive "ON-OFF" loads up to 1100 psi. New Oilgear type "ANP" pumps will perform more efficiently — with less heat generation — on presses, machine tools, transfer machines, hold-downs, injection molding, die casting — and other machines.

For complete data on these new "Power-Saver"—Oilgear type "ANP" Pumps — call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, requesting your copy of Bulletin 47550 — stating your specific requirements directly to . . .

SELECTION OF MOUNTINGS

Pump case has an accurately finished round face for:

1. Mounting direct to machine. (above)
2. Mounting to a right-angle bracket for "foot-mounting." (right)
3. Mounting to a round adapter for NEMA type "C" electric motor frames.
4. As Standard and "Custom-Built" "Power-Paks"—(right) . . . . complete, compact sources of Fluid Power. Standard "Pak" consists of "ANP" Pump with round adapter or right-angle bracket, coupling, electric motor, 23-gallon differential capacity welded steel base, piping, air breather, filling strainer, fluid level gauges, baffles, clean-out covers, drain plugs, auxiliary pipe connections, and mounting and leveling lugs.



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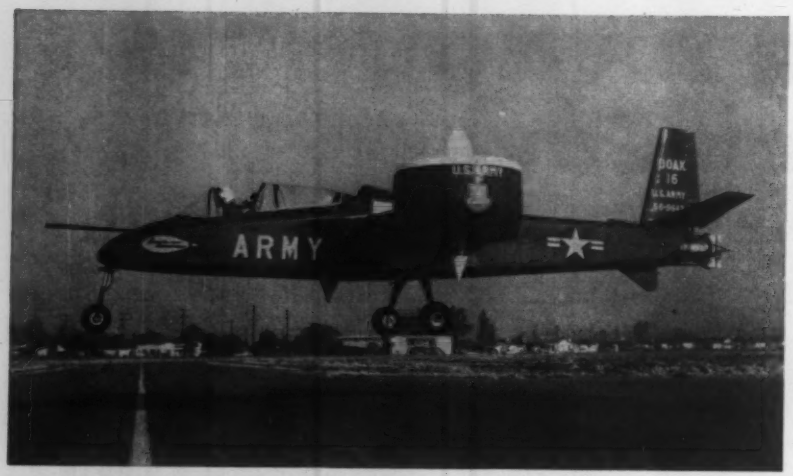
Application-Engineered Controlled Motion Systems

1568 WEST PIERCE STREET • MILWAUKEE 4, WISCONSIN

Oilgear's *"Power-Saver"* Pumps and simplified circuitry reduces engineering, production and assembly costs . . . promotes safety, improves performance and system efficiency.

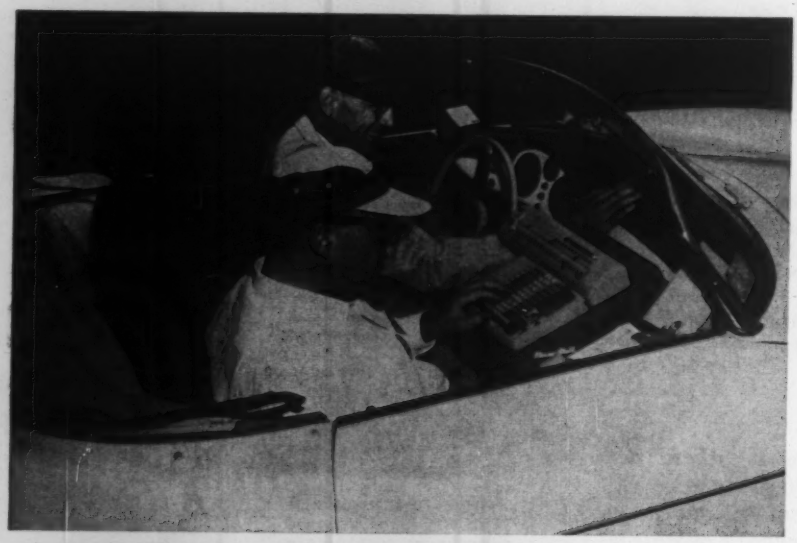
Please direct inquiries to advertiser, mentioning MACHINE DESIGN

chines whether an inventor's jet engine or chemical process is already old, and to get an answer in a trice. He will get, not a simple yes or no, but a list of any patents and technical papers that may block the application.



First Flight of the Doak 16

A milestone in Army's search for VTOL aircraft was passed recently when the twin-duct Doak 16 made its first successful hovering flight. Next stop for the craft is NASA's High Speed Flight Station at Edwards AFB for complete flight testing. Doak's ducted wingtip propellers rotate 90 deg for transition from vertical to horizontal flight. Where airports are available the craft will always take off horizontally—which requires less power and permits carrying extra fuel and payload. Built by Doak Aircraft Co. Inc., the plane is powered by an 825-hp Lycoming T-53 shaft-turbine engine.



Porsched Computer Wins Sports-Car Rally

By figuring distances to within 0.001 mi, two missile engineers and a calculator riding in a Porsche easily won a precision driving contest in New Mexico. The contest required exact maintenance of a predetermined speed over a several-hundred-mile route. The engineers, D. F. Bellof and J. R. Pearson of Telecomputing Corp., took turns driving and feeding data from a tachometer and chronometer into the calculator to determine speed corrections every 3 min. Their calculations included an allowance for tire expansion due to heat.

Topics

Missiles ride on air in railroad cars fitted out by New York Central to provide virtually shock-free ground transportation for these delicate passengers. In an over-sized baggage car are big rubberized pillows, filled with air or carbon dioxide, which support missile or missile components and absorb the shocks that occur during normal rail travel. Cost of such a ride is about half that of air transportation.

• • •

Paper money dispenser developed in Great Britain can make quick work of a large payroll. Pressing numbered pushbuttons feeds the appropriate number of each denomination from the hopper to the pay-envelope stuffer. The foldin' green stuff sl'ps through the machine's electronic fingers at the rate of 40,000 bills per hour.

• • •

1959 twin-lever Model T, built to celebrate the Tin Lizzie's golden anniversary, recently rolled off Ford's Mahwah, N. J., assembly line. Parts of the car, assembled by hand and untouched by production-line hoists and cranes, include the wooden body and chassis from an early T, custom-made fenders and wheels, and various items from antique shops. The venerable buggy sat tall on the line —a full 2¼ ft above the 1959 models surrounding it. It is 6 ft shorter and weighs only about one-third as much as the new cars. More precious even than this generation's T-bird, the flivver is valued at $5000. However, it isn't for sale, but will be placed in the Henry Ford Museum in Dearborn, Mich.

• • •

Hoops for satellites will keep the craft properly oriented, according to Robert P. Haviland of GE's Missile and Space Vehicle Dept. Mr. Haviland has patented a "liquid flywheel," a hoop-like arrangement of pipes through which liquid is pumped at varying speeds. Changing flow rate and direction will stabilize the satellite.

• • •

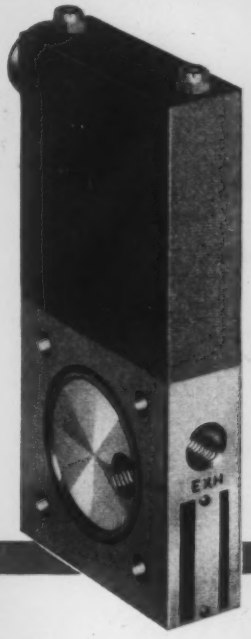
Computer will make educated guesses to fill blanks on incomplete cards when tabulating the next U.S. Census. The machine will store instructions for obtaining related information that the census-taker forgot to record. For example, a person who should have been but wasn't designated "female" is likely to be referred to as "wife" elsewhere; the computer will check this and indicate the proper sex. The 1960 nose-count will be the first decennial census to be tabulated entirely by electronic computers. Mechanization is expected to shave a year and a half off the usual time required to publish statistics.

Introducing the new

HUNT

Slim Line VALVES

SOLENOID, SINGLE PILOT
DOUBLE PILOT, LEVER
OR BALL ACTUATED



ONLY 1" THICK BY 3" WIDE

Compact, light in weight, and easily manifolded, these new Hunt valves have been designed specially for use when mounting space is limited. Ideally suited for controlling small cylinders, or to operate diaphragms, pilot cylinders or other devices. Pressures to 125 psi.

Proven, dependable Hunt construction, with hollow, radially ported stainless steel plunger; and "O"-ring seals accurately positioned with metal spacers, held rigidly in metal to metal end abutment. No lapped joints and no rubbing of metal against metal to cause wear, assuring long, efficient, maintenance-free operation.

Easily manifolded. The side of each valve is counterbored; trepanned for an "O"-ring and provided with four through holes. This permits up to eight valves to be manifolded together in any of four 90° angle positions, and operated simultaneously from a single supply;— or up to sixteen valves from two supply sources.

More startling HUNT designs to come!

Send for the "SLIM LINE" Bulletin No. 581 TODAY!

HUNT
Quick-As-Wink*® AIR AND HYDRAULIC CONTROL *Valves

Manufactured by HUNT VALVE COMPANY, 2012 East Pershing St., Salem, Ohio

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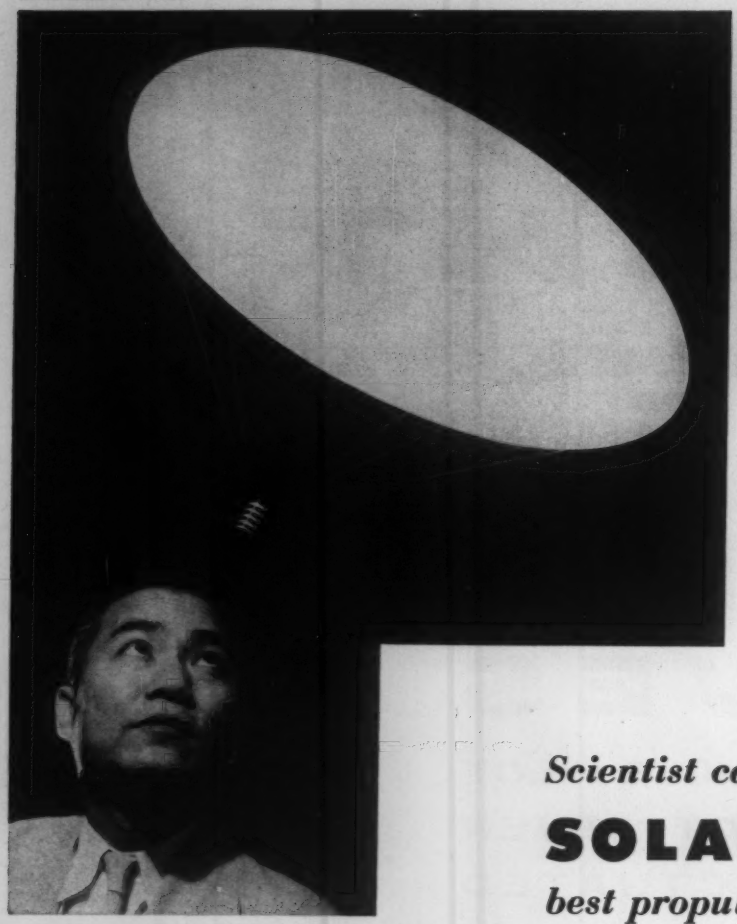
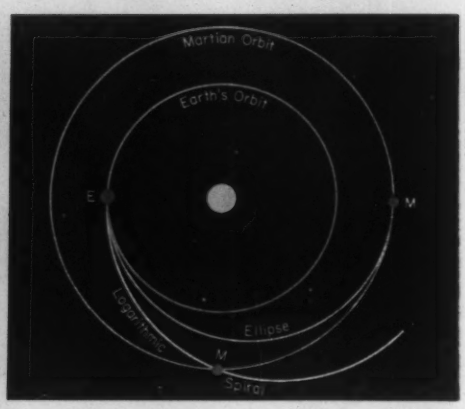


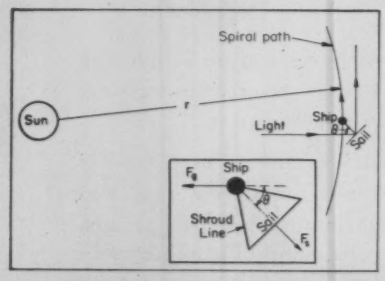


On a trip to Mars, the solar sail takes only 118 days, compared to 260 days by rocket. After burnout, the rocket must follow a transfer ellipse; it has to travel 180 degrees from one side of the sun to the opposite side. The solar sail, however, follows a logarithmic spiral—a short-cut from earth's orbit to the Martian orbit. Dr. T. C. Tsu, left, examines a model of the solar sailboat

Scientist calls

SOLAR SAIL

best propulsion for space travel



Sailing toward the sun is easier than sailing into the wind. Force F_g denotes the sun's gravitational attraction. Force F_s is the solar-radiation pressure falling on the sail. F_s may be resolved into two components, tangential and normal to the spiral path. When the sail is moved from the position shown to a mirror-image position above the horizontal line, the tangential component of F_s changes direction—now speeding up rather than slowing down the space ship. The result is an ever-widening logarithmic path. In other words, when the sail is "tacked" back and forth, the space ship will either fall toward the sun or climb away from it.

PITTSBURGH—Using radiation pressure from the sun—just as a conventional sailboat makes use of wind—is the cheapest, simplest, and lightest means of propulsion for man's exploration of space, according to Westinghouse scientist Dr. T. C. Tsu. And the solar sailboat can be made operational sooner than rocket - powered vehicles, says Dr. Tsu, since no research is needed beyond present knowledge.

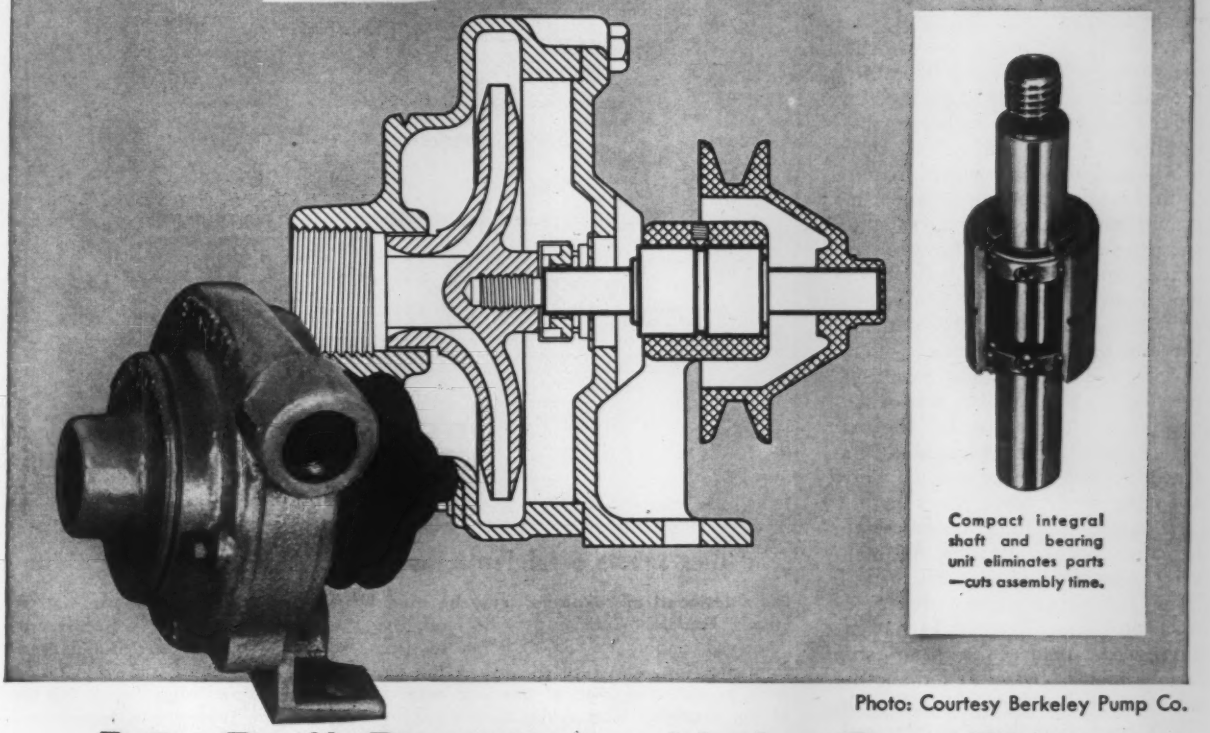
Resembling a huge parachute, the sail would be made of aluminum foil or lightweight plastic material no more than 0.0001 in. thick, and would be attached by shroud lines to a passenger gondola. For a payload of 1000 lb, the required sail diameter would be about 1600 ft—

Destination Mars: Solar Sails vs. Chemical Rockets

Performance	Solar Sail	Chemical Rocket
Mass Ratio* (one way trip)	1	9
Mass Ratio* (round trip)	1	73
One way trip (days)	118	260
Time to escape earth	several weeks	negligible
Time to adapt to orbit around Mars	several weeks	negligible

*Ratio of initial mass (prelaunch) to final mass of the space ship for earth orbit to Mars-orbit voyage.

CASE HISTORIES



Compact integral shaft and bearing unit eliminates parts —cuts assembly time.

Photo: Courtesy Berkeley Pump Co.

Ball Bearings Help Cut Size... Lower Costs $2.50 Per Pump!

CUSTOMER PROBLEM:

Redesign utility water pump for Air Conditioner market. Conversion must achieve smaller size without reducing pump capacity. At the same time, customer must lower over-all production costs.

SOLUTION:

N/D Sales Engineer suggested the versatile New Departure fan and pumpshaft ball bearing. This compact precision bearing permitted use of over-the-housing pulleys with belt load located over the raceway. Its integral shaft, which is the inner race, simplified design and helped reduce housing size without changing pump capacity. In addition, the sealed and lubricated-for-life bearing replaced two sealed bearings, separate shaft and snap rings . . . cutting part and assembly-time costs $2.50 per pump.

Perhaps one of New Departure's wide selection of *production* ball bearings will help give *your* product the sales appeal and cost savings you're looking for. For more information, call the New Departure Sales Engineer in your area or write Dept. Q-11.

Available through United Motors System and its independent Bearing Distributors.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

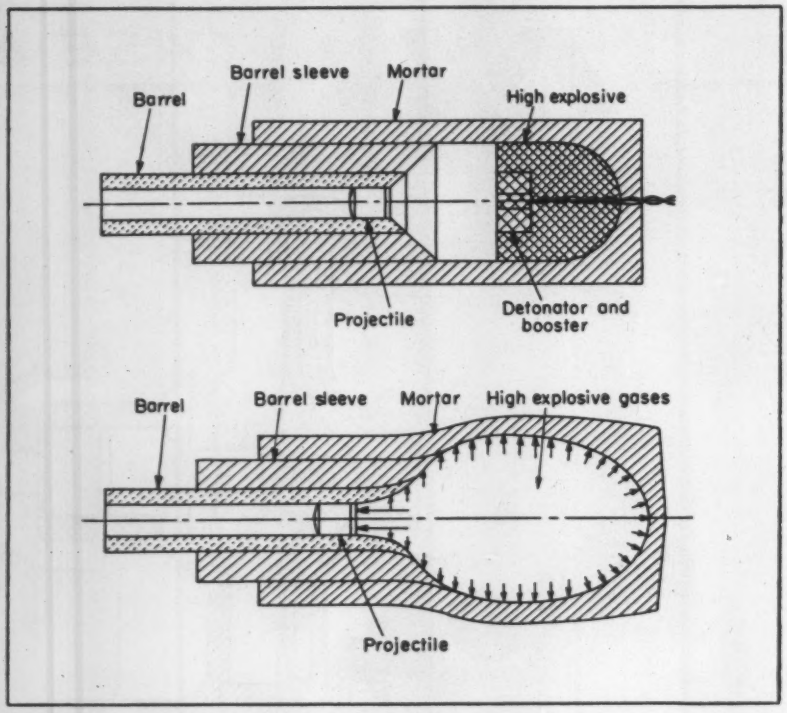
NOTHING ROLLS LIKE A BALL

giving an area somewhat larger than the pentagon building. The tremendous surface area could double as an excellent radar antenna.

Shot from the earth by conventional rocket, the solar spaceship would first be placed in orbit at an altitude of 1000 mi. Once in orbit, the rocket would be discarded, and the sail unfurled. Total force acting on the sail would be rather small—not quite ½ lb during the earth orbit—and the ship would require several weeks to escape from earth's gravity and become a solar satellite, spiraling around the sun. Once in space, however, the ½ lb thrust would slowly accelerate the vehicle to speeds reaching 50,000 mph near the end of a trip to Mars.

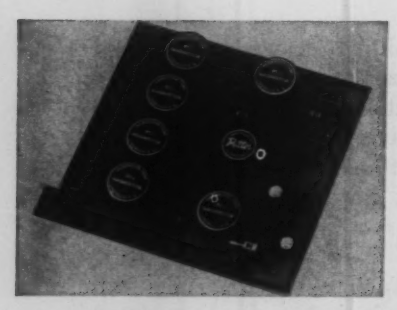
Solar-sail "deckhands" would be busy while the sailboat was still a captive satellite of earth. The sail would have to be dropped during travel toward the sun, hoisted when traveling away from the sun.

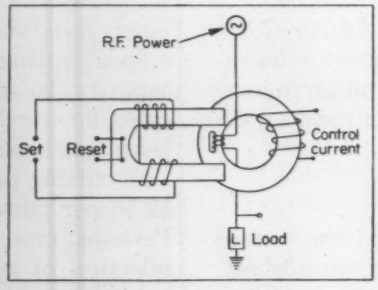
In space, the ship's course would be controlled by turning the main sail, or by hoisting an auxiliary sail. This greatly simplifies space guidance problems. If errors in navigation were made, the solar ship would merely heave-to for another try—a fact that further justifies Dr. Tsu's prediction that the solar sailboat may be man's best transportation to nearby planets.



Lead Gun Shoots Steel Projectile

Guns designed to "explode" may be used by the Army for hypersonic testing of missile models. Built largely of lead, the guns will propel steel projectiles at velocities ranging to 15,000 ft per sec (some six times faster than a bullet fired from the Army's M-1 rifle). In the top diagram, the projectile is shown in place with a protective disc of phenolic resin behind it. Below, after firing, inertia of the distorted lead walls confines the gases until the projectile is forced forward. The steel barrel also expands, but the projectile moves forward fast enough to keep ahead of expansion. General Electric's Missile and Space Vehicle Dept. is evaluating the new research tool under Army contract





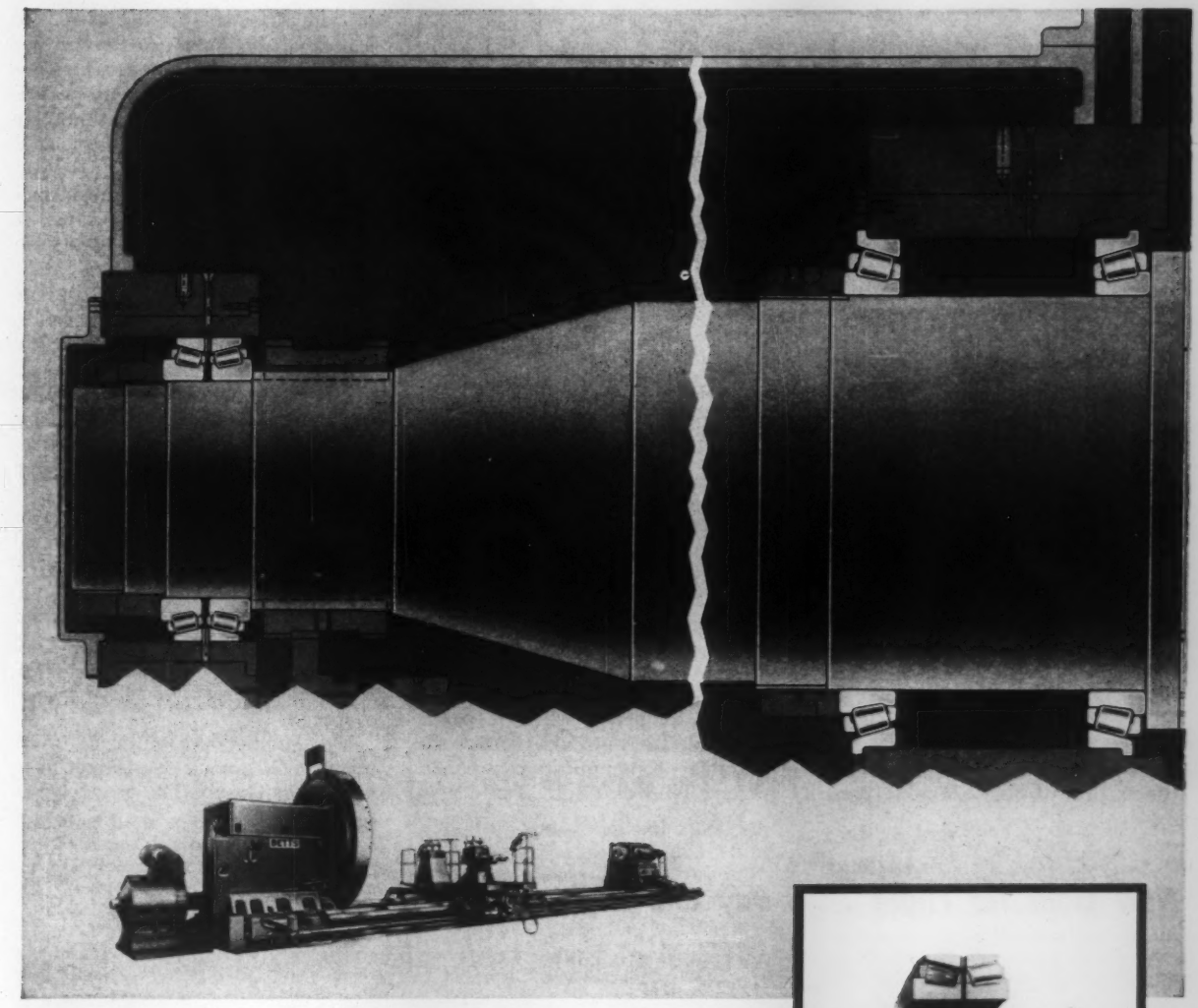
Tiny Component Stores, Compares Data Pulses

A dime-sized magnetic component—called Magnistor—stores, analyzes, and compares digital pulses and is said to cut size and cost of electronic computers by one-third. Signal inputs enter on two terminal pairs: 1. **"Set,"** associated with a high-retentive (permanent-magnet) loop. 2. **"Control Current,"** associated with a low-retentive (temporary-magnet) loop. Magnetic states possible for the combination are off-off, on-on, off-on, and on-off. Differentiation of signals is given by the saturated or unsaturated flux state in a radio-frequency power-winding core. Made by Potter Instrument Co. Inc., Plainview, L. I., N. Y., Magnistor has wide potential for application in data handling equipment, high-speed printers, computers, and similar digital devices. Panel shows component arrangement in a high-speed page-printer and data lister.

Electroluminescent Safety Light Runs a Year on a Penny

PITTSBURGH—An electroluminescent safety "lamp" that has no filament, produces practically no heat, is glare-free, and burns continuously for a year for less than a penny, will be available to the public for the first time this winter. Measuring 2¾ by 2¼ in., the lamp fits flush against a standard outlet.

Barely visible during the day, at night the safety light provides a pleasing, soft-green glow for stairways, hallways, or bathrooms. Rated 1/200 w (115 v), the unit has a life of 10,000 hours—more than ten timts that of a conventional household incandescent lamp. Westinghouse Electric Corp. will market the lamp under the name "Rayescent Safety Light."

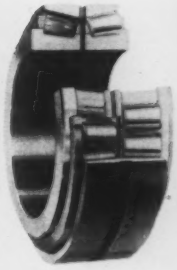


Torrington ultra-precision in large sizes!

The two-row Tapered Roller Bearing shown above is 21.5000″ OD, has a maximum radial and face runout of .0003″, with rotating inner ring and stationary outer ring. At 100 rpm, its radial capacity is 304,000 pounds, its thrust capacity 215,000 pounds.

The single-row Tapered Roller Bearing is 36.000″ OD, with a maximum radial and face runout of .0003″. At 100 rpm, its radial capacity is 319,000 pounds, thrust capacity 272,000 pounds.

Precision in large bearings reflects Torrington's specialized skills and equipment, which enter into the production of every Torrington Bearing, large or small, special or standard. You may not require such precision, but you can be sure your bearing order will receive the care that makes Torrington quality a by-word of industry. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**



These ultra-precision Tapered Roller Bearings were specially designed and built by Torrington for Consolidated Machine Tool Company's 144″ lathe front and rear-head-block positions.

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

TAPERED ROLLER • SPHERICAL ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

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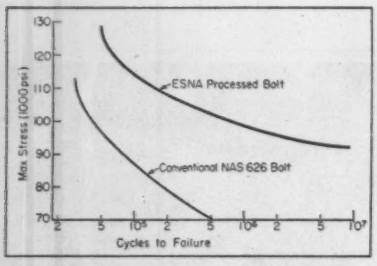
Bolt Fatigue Life Multiplied By New Thread Process

Finds First Application On Aircraft Fasteners

UNION, N. J.—New high-strength bolts are said to have thirty times the fatigue life of standard bolts of the same strength rating. Unique thread manufacturing technique is responsible, say developers, Elastic Stop Nut Corp. of America, Union, N. J.

They point out that threads conform to existing drawings and can be inspected with standard thread gages. So far only high-strength aircraft bolts have been produced, but the process is applicable to any bolt or screw. Laboratory tests show that a ¾-in. bolt threaded by the new method has the same high fatigue level as a ⅜-in. bolt.

Bolts made by the new process might be used either at present stress levels to provide practically infinite life, or could be used with higher design loads to give the same life as present bolts. Another possibility anticipated is more compact design by reducing the required number of engaged threads. Process is now being patented by ESNA.



Comparison of stress vs. cycles to failure for conventional and "processed-thread" bolts. Fatigue life of the new bolt approaches infinity for repetitive stresses in the 90,000-psi range.

Too Many Satellites May Be Headache

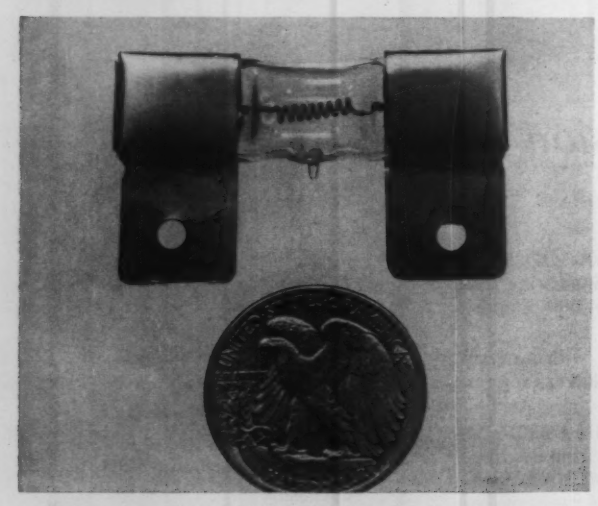
CLEVELAND—An uncontrolled number of satellites, each monopolizing a radio frequency when it passes overhead, could quickly saturate the available communications bands, warned NASA's A. O. Tischler in an address to the Cleveland-Akron branch of the American Rocket Society. Looking to the future, he suggested that radio equipment carried on planetary probes might not be powerful enough to penetrate such a barrier.

The problem is not entirely academic, since the NASA plans to make available a cheap satellite system labeled the "poor man's satellite" by Mr. Tischler. The system is based on the use of four solid-fuel rocket stages, three of which are now in existence. The rocket, which is capable of putting about 100 lb in orbit at 300 miles, will be made available to responsible scientists and research laboratories here and abroad.

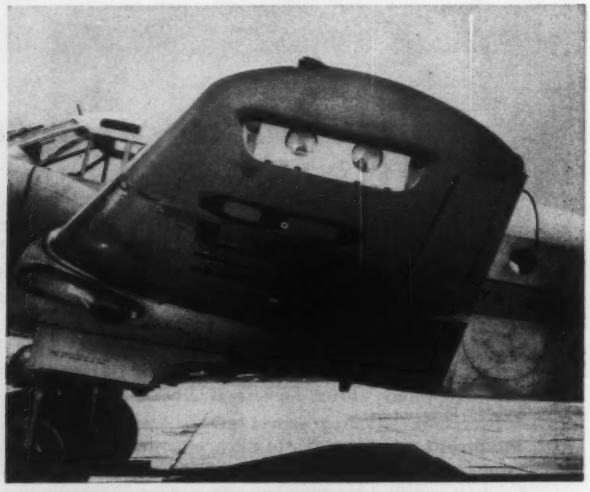
Satellites now in orbit demonstrate the extent of the communication problem. The predicted life of Vanguard I, put into orbit on March 17 of this year, is 200 years. Its sun-powered radio as yet shows no sign of failing and monopolizes a wavelength every time it passes overhead.

Mr. Tischler also outlined future plans of NASA's Space Flight Development Group. The group is re-

New Light for Flight . . . Day and Night

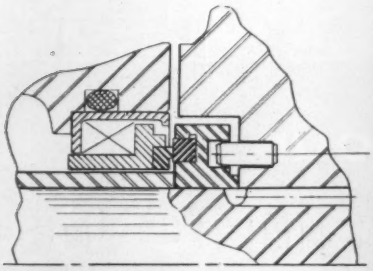


A miniature wingtip identification lamp for supersonic jet aircraft produces twice as much light as two ordinary 100-w bulbs. Developed by General Electric, the 28-v tubular-quartz lamp is called the most compact commercially available tungsten filament lamp of comparable wattage in the world. Only 2¼ in. long by ½ in. diam, it has a service life of 300 hr. The fused-quartz envelope of the lamp can withstand severe mechanical strain—when cracking the sound barrier, for example—and extreme temperature variations.



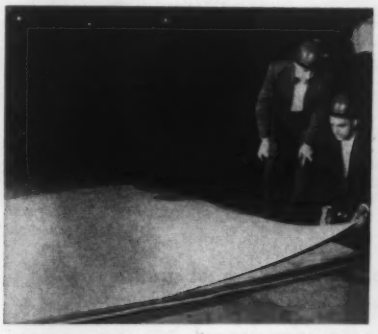
Flashing lights, bright enough to be seen for miles, are another proposal for aircraft collision avoidance. Prototype system, developed by Minneapolis-Honeywell and the Atkins Light Co., has been installed on Twin Beech aircraft for evaluation by Airways Modernization Board. Production system would be integrally mounted in wingtips or fuselage. The high-intensity flashing lights, used day and night, would supplement a plane's conventional lighting system for added safety in crowded airlanes.

viewing current civilian space projects and formulating future NASA space tasks.



Seal Runs Fast and Dry

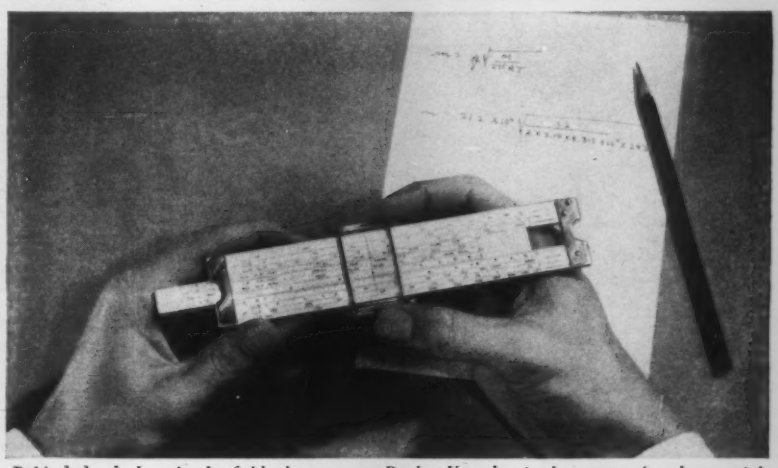
Holding pressures up to 150 psi at temperatures to 600 F, the carbon faces of this seal will tolerate rubbing speeds up to 12,000 fpm dry. Special treatment given the carbon faces makes them more compatible than any other combination of seal materials now in use. Applications range from air-operated chucks to afterburner fuel pumps and water-injection pumps in jet engines. Afterburner fuel pumps are directly geared to the engine and rotate continuously; however, they are lubricated by fuel for only about 2 minutes out of every 8 hours of operation. The seal is designated PS-113 by its developers, Sealol Corp., Providence, R. I., and is available to fit shafts from 1/4 to 4 in. diam.



Pack-Rolled Sheet Widest Yet

Wider by one-third than the largest steel sheet previously rolled, a new "pack-rolled" 160-in. sheet permits design of missiles and rocket motors with a minimum number of welded joints. The pack-rolling technique — which sandwiches the high strength steel between two cover plates—permits multidirectional rolling resulting in more precise weight control. The sheet was rolled by Lukens Steel Co. on its 206-in. plate mill, largest in the nation.

DRAFTING TRENDS



Behind the desk or in the field, the compact Pocket Versalog is the answer for those quick calculations. Weighing only 1½ ounces and having 23 versatile scales, the Pocket Versalog is designed for professional people in all fields of engineering.

Pocket Versalog changes concept of pocket slide rules

Today's engineer must have a slide rule of professional quality . . . with a full range of scales necessary for rapid calculation . . . to solve a variety of problems, accurately and easily.

That's a lot to expect of a standard sized slide rule. It is even more to demand of a pocket rule . . . and, of course, that is the primary reason why 5" slide rules are not used extensively by many engineers, despite the convenience they seem to offer.

A new concept of pocket rules is likely to change this viewpoint, due to the recent introduction of the Pocket Versalog. Here is a slide rule that weighs a mere 1½ ounces, is only 6¾" long, yet contains 23 versatile scales for rapid, surprisingly accurate answers to problems in every field of engineering.

The Pocket Versalog accurately duplicates the famed 10" Post Versalog, with every feature that has made it by far the most universally approved slide rule on engineering campuses today. For example, the same R_1 and R_2 scales permit square root computations with far greater accuracy than A and B scales . . . four log log and four reciprocal log log scales give tremendous versatility . . . and the same new end zone designations of log and log log reciprocal scales speed calculations.

Other features include exclusive color coding of the trigonometric scales which simplifies their use in many ways. In addition, the appearance of the C and D scales on *both* sides of the rule permits easier solutions to many problems.

Built to last

Laminated bamboo is the Pocket Versalog's secret to long life. Only bamboo gives you so many advantages: Protection against warpage, since it resists humidity to a high degree. Natural sealed-in silica, which actually makes the rule function more smoothly as the years go by *without ever requiring lubricants.* A slide that moves perfectly, never too loose nor too tight.

The precision graduations cut into the white celluloid face remain accurate and readily visible during the entire lifetime of the rule, thanks to the extremely accurate engine-dividing of each graduation. Lines are razor sharp . . . they will not smear, fade nor vary.

Convenient to carry in office or on the job, Post's Pocket Versalog is furnished in a handsome leather case with pocket clip. It is lighter, smaller, more compact than any other advanced slide rule on the market.

For more information on the Pocket Versalog, see your local Post blueprinter or write today to Frederick Post Company, 3652 North Avondale Avenue, Chicago 18, Illinois.

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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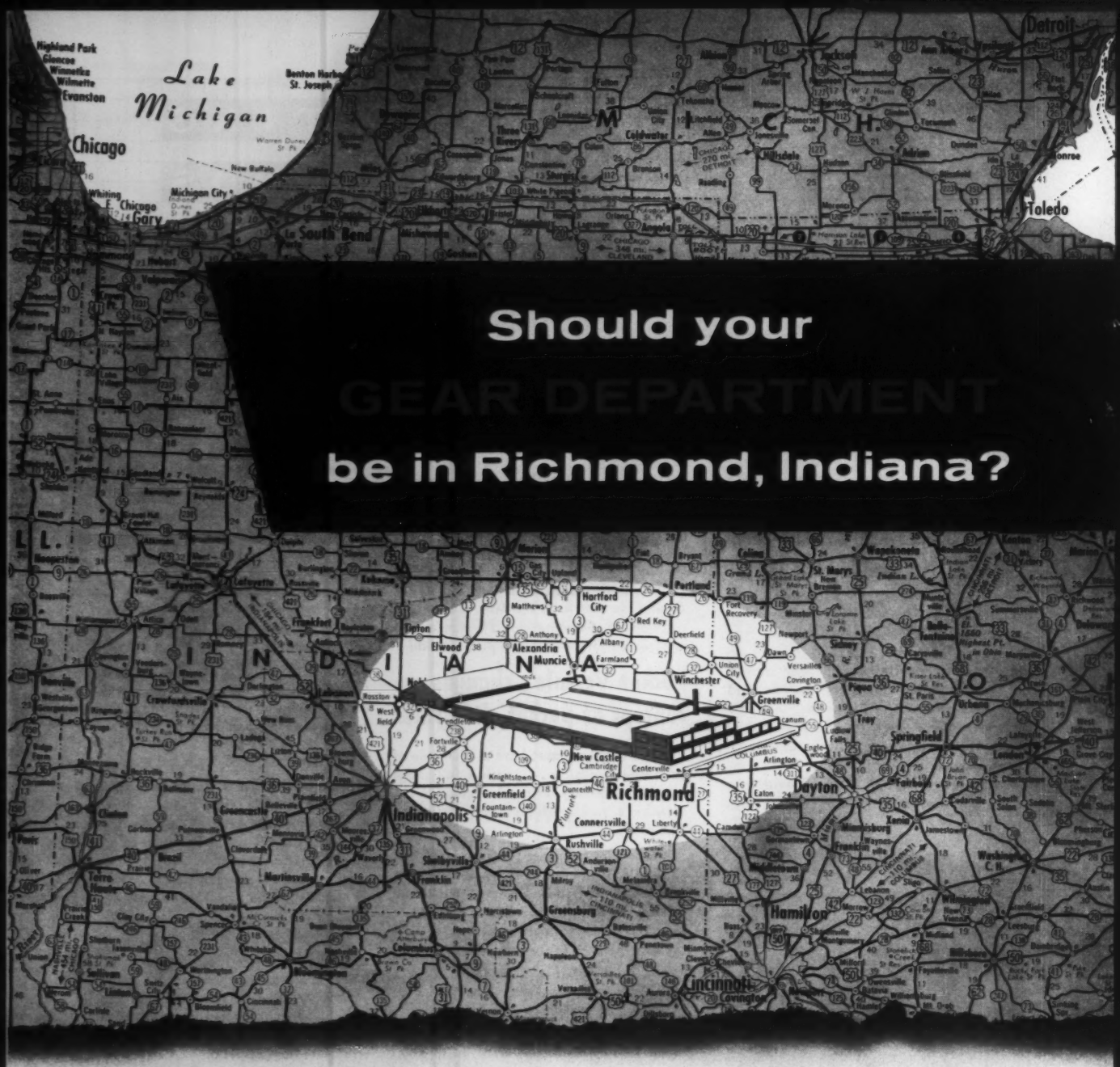

Today, that's a better question than ever. The current completion of 65% additional square feet of production capacity further improves our position to serve as your *gear department.*

Many of our best customers use us in this manner with all of our facilities geared to their gear needs. Would you like to learn how successful these associations have been, and what a similar service might mean in terms of reduced costs and better gears?

If so, write. The man who responds to your inquiry will be a gear engineer.

EATON

AUTOMOTIVE GEAR DIVISION
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RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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MACHINE DESIGN

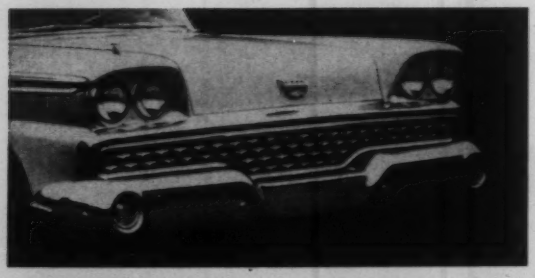
High-styled power: the '59s

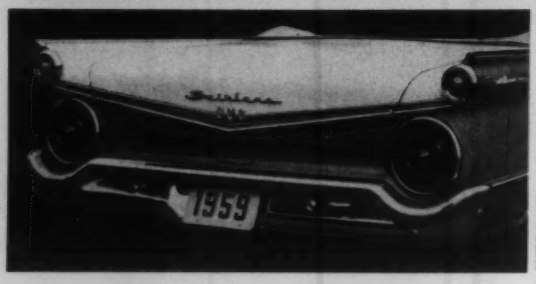
part 3

MD's SURVEY OF NEW CARS concludes in this issue with a look at engineering features incorporated in the '59 Ford lineup. A summary of engine specifications of all 1959 cars is also included.

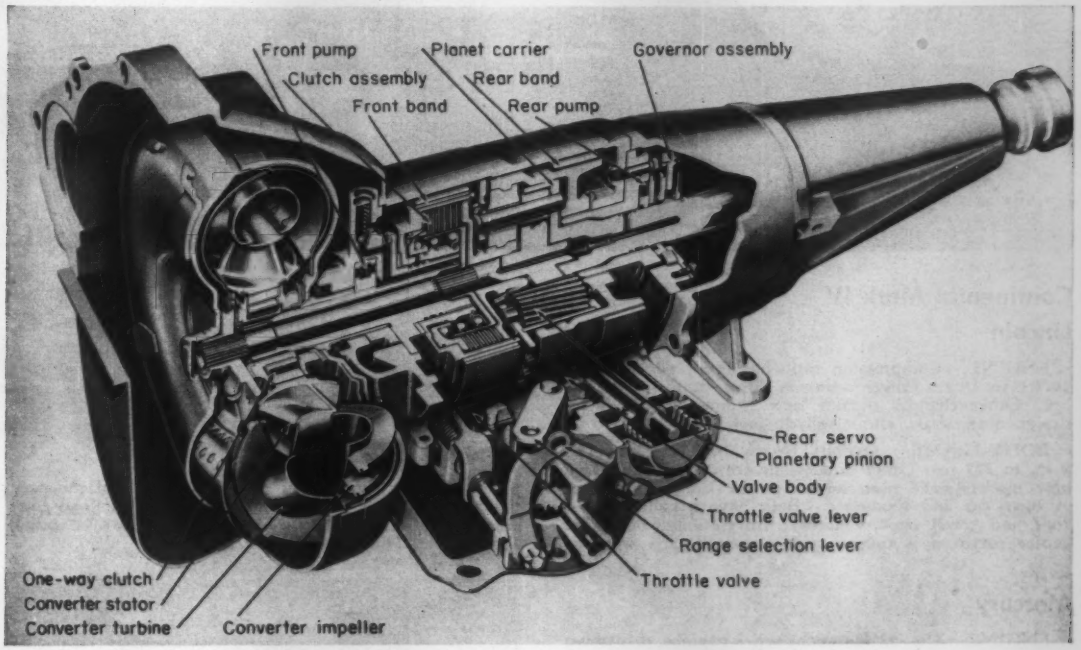
The new model year is off to an impressive start. Largely responsible, of course, are drastic styling changes which seem to appeal to the public. Appearance overhaul, in most cases, has been accompanied by significant engineering improvements. One new model, for example, boasts an increase in length of about 5 in.—always a good sales point. Engineers also made use of the added space by moving engine, transmission, and front wheels forward, and reducing height of the drive-line tunnel in front and rear seating areas.

Almost all '59 cars feature new exterior finishes, some of which need no waxing for the lifetime of the car. Mufflers, a perennial problem on most models, have been improved in quality by aluminum coatings and by the simple procedure of using heavier gage metal; they should last twice as long as last year's exhaust systems, according to their manufacturers.



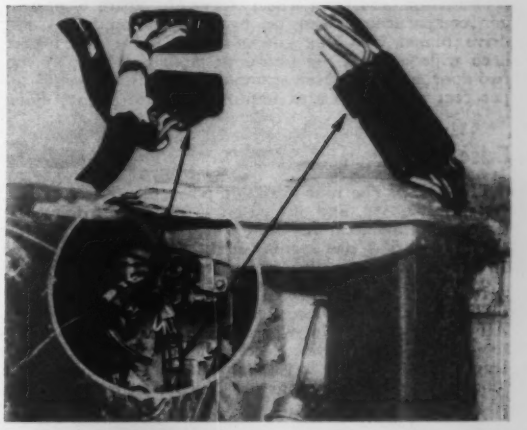


Ford line, '59: Easy on styling, emphasis on refinement . . .



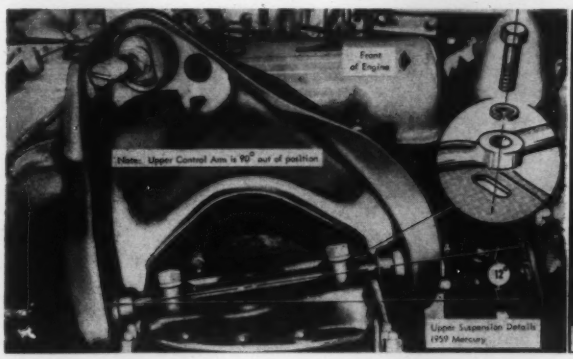
New two-speed transmission, available on Ford, Edsel, and Mercury, has 105 fewer parts and weighs 50 lb less than last year's Fordomatic. The unit is contained in a one-piece aluminum housing. A three-element torque converter is coupled to a compound planetary gear set made up of two sun gears, two sets of pinions, and one internal gear. The planet carrier is the output member; brake bands are the reaction members. Front band holds the front sun gear to provide reduction in low-speed forward. Rear band holds the internal gear to provide reduction in reverse. Driver has choice of two forward speeds: Low and drive, plus reverse, neutral, and park. With the indicator in drive position, the car starts in low and upshifts to drive speeds dependent upon throttle pressure. Kickdown to low for passing at speeds up to 55 mph is automatic.

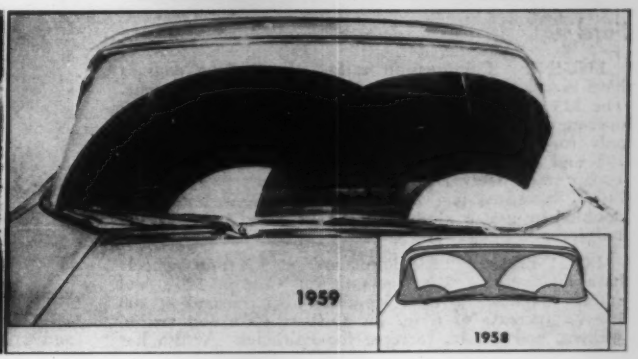
Quick-disconnect electrical system is a new aid to maintenance and repair on '59 Mercurys.

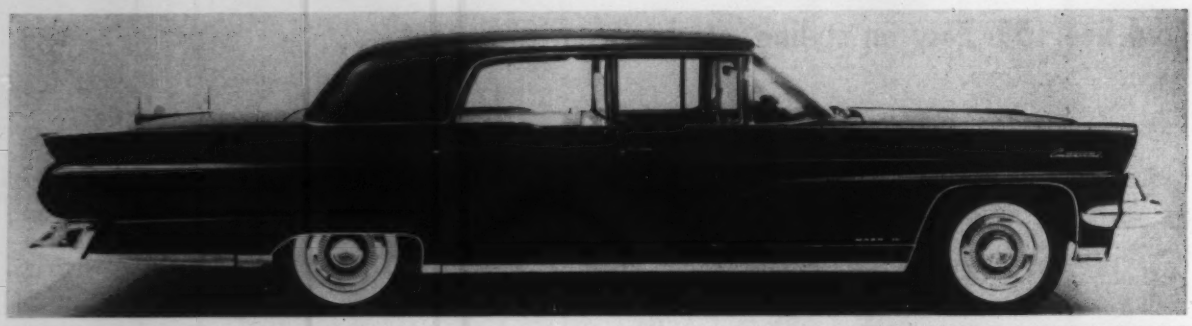


Better caster-camber adjustment has been incorporated in Mercury's front suspension. Upper arm shaft attaching plate has slotted bolt holes to allow lateral movement of the shaft. Bolt boss surfaces are knurled to provide a sure, permanent grip. Shims were formerly used to make the adjustment.

Redesigned windshield wipers operate in tandem on the '59 Mercury and leave no center blind spot. Blades are 16 in. long, 4 in. longer than last year, and clean 43 per cent more windshield area.





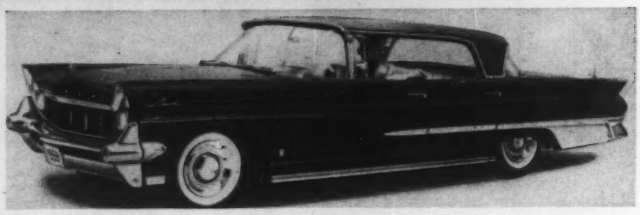


Continental Mark IV

Lincoln

ENGINE: Compression ratio has been reduced from 10.5:1 to 10:1. Power rating is down from 375 to 350 hp. Other changes include new engine mounts, a redesigned camshaft, and magnetic fuel filter.

BODY-FRAME: Overall length has been reduced 2 in. to 227 in. Other dimensions are unchanged. Two new models have been added to the Continental line: A town car and limousine. Both have a padded vinyl roof and small back window. An optional limousine center partition is topped with a curved-glass window,



power-operated from front or rear. Center of the partition base facing the rear seat houses an inclined console with controls for rear seat radio and various other accessories. Power lubrication is optional.

Mercury

ENGINE: The '58 Marauder-series engines, displacing 312, 383, and 430 cu in., are largely unchanged. Power ratings range from 235 to 345 hp. A 400-hp Super Marauder, offered last year, will probably be available in '59.

BODY-FRAME: Major chassis redesign puts a 126 in. wheelbase under Monterey and Monclair models, 4 in. longer than last year. Park Lanes have a 3-in. longer wheelbase, for 128 in. Overall car length has grown accordingly. Space gained was used to move engine, transmission, and front wheels forward. Space in passenger compartment taken up by transmission hump and drive tunnel has been cut in half. Front doors have been widened 4 in. on four-door models and 2½ in. on two-door models. New compound windshield with 60 per cent more glass area improves upward vision; hood

is 2½ in. lower for better road vision, and the instrument panel has been moved forward 6 in. for more knee room.

ACCESSORIES: Improved power steering is said to require 50 per cent less effort in parking, 15 per cent less effort in normal driving. Self-adjusting brakes are standard equipment.

Edsel

ENGINE: The four available powerplants—223 cu-in. six and 292, 332, and 361 cu-in. V-8's—have lower compression ratios than in '58 (9.6:1 is highest). All but the biggest V-8 use regular fuel. Power rating of the 361 cu-in. engine is also down: From 345 to 303 hp.

BODY-FRAME: Three series—Ranger, Corsair, and Station Wagon—replace last year's four-series lineup. All '59s have a 120-in. wheelbase, giving a 2-in. increase for Ranger series, 4-in. decrease for Corsairs. Overall length of all models is 210.8 in., a 5-in. cut for Corsair models. Other dimensions are largely unchanged.

ACCESSORIES: Ford's new economy two-speed auto-

matic transmission is available on all models excepting those powered by the Super Express engine. Automatic lubrication is optional.

Ford

ENGINE: Compression ratios of all four engines have been reduced this year as Ford emphasizes economy. The 223 cu-in. six, and the 292 and 332 cu-in. V-8's will operate on regular fuel; premium grade is recommended only for the 392 cu-in. engine. Power ratings of the 292 and 332 cu-in. engines have been reduced 5 and 15 hp respectively (down from last year's 205 and 240 hp). Exhaust-system life on all engines is reportedly doubled by use of aluminized mufflers and heavier gage tailpipes.

BODY-FRAME: All Fords are on a 118-in. wheelbase this year, a 2-in. increase for Custom 300's and station wagons. Overall length is also constant at 208 in.—an increase of 6 in. for Custom 300's and station wagons, and a 1-in. increase for Fairlanes. Width has

been cut 1.4 in.

ACCESSORIES: Two-speed Fordomatic transmission and a Ford-designed nonslip differential are new.

Power behind the style: '59 engines

The trend in engine refinement this year was toward economy, not power. Most manufacturers are featuring another version of their standard engine in which power is sacrificed for better gas mileage. Versatility is epitomized in the case of one new model (Pontiac): The same basic engine is offered in power increments ranging from 215 to 345 hp. It's all done with carburetors, camshafts, and other modifications, without changing bore and stroke.

8s

Make and Model	Basic Engines*	Bore & Stroke (in.)	Displacement (cu in.)	Compression Ratio	Power, max (bhp)	Torque, max (lb-ft)	Carburetor†	Fuel Recommended§
AMBASSADOR	1	4 x 3.25	327	9.7:1	270 @ 4700	360 @ 2600	4b	P
BUICK	2							
LeSabre		4.12 x 3.40	364	10.5:1	250 @ 4400	384 @ 2400	2b	R
Invicta, Electra		4.19 x 3.64	401	10.5:1	325 @ 4400	445 @ 2800	4b	P
CADILLAC	1							
60, 62, 75 Series		4.00 x 3.87	390	10.5:1	325 @ 4800	430 @ 3100	4b	P
Eldorados		4.00 x 3.87	390	10.5:1	325 @ 4800	435 @ 3400	4b	P
CHEVROLET	2							
Standard		3.87 x 3.00	283	8.5:1	185 @ 4600	275 @ 2400	2b	R
				9.5:1	230 @ 4800	300 @ 3000	4b	P
				10.5:1	250 @ 5000	305 @ 3800	FI	P
				10.5:1	290 @ 6200[1]	290 @ 4400	FI	P
Optional		4.12 x 3.25	348	9.5:1	250 @ 4400	355 @ 2800	4b	P
				9.5:1	280 @ 4800	355 @ 3200	Three (2b)	P
				11:1	300 @ 5600[1]	350 @ 3600	4b	P
				11:1	315 @ 5600[1]	356 @ 3600	Three (2b)	P
CHRYSLER	2							
Windsor		4.03 x 3.75	383	10:1	305 @ 4600	.....	2b	R
Saratoga		4.03 x 3.75	383	10:1	325 @ 4600	.....	4b	P
New Yorker		4.18 x 3.75	413	10:1	350 @ 4600	.....	4b	P
300 E		4.18 x 3.75	413	10:1	380 @ 5000[2]	.....	Two (4b)	P
CONTINENTAL	1	4.30 x 3.70	430	10:1	350 @ 4400	490 @ 2800	4b	P
DESOTO	2							
Firesweep		4.12 x 3.38	361	10:1	290	390 @ 2400	2b	P
Firedome		4.25 x 3.38	383	10.1:1	305	410 @ 2400	2b	P
Fireflite		4.25 x 3.38	383	10.1:1	325	425 @ 2800	4b	P
Adventurer		4.25 x 3.38	383	10.1:1	350	425 @ 3600	Two (4b)	P
DODGE	3							
Red Ram		3.95 x 3.31	326	9.2:1	255 @ 4400	350 @ 2400	2b	R
Ram Fire		4.12 x 3.38	361	10.1:1	295 @ 4600	390 @ 2400	2b	P
Super Ram Fire		4.12 x 3.38	361	10.1:1	305 @ 4600	400 @ 2800	4b	P
D-500		4.25 x 3.38	383	10:1	320 @ 4600	420 @ 2800	4b	P
Super D-500		4.25 x 3.38	383	10:1	345 @ 5000	420 @ 3600	Two (4b)	P
EDSEL	3							
Ranger		3.75 x 3.30	292	8.8:1	200 @ 4400	285 @ 2200	2b	R
Corsair		4.00 x 3.30	332	8.9:1	225 @ 4400	325 @ 2200	2b	R
Corsair (opt.)		4.05 x 3.50	361	9.6:1	303 @ 4600	390 @ 2900	4b	P
FORD	3							
Custom, Fairlane		3.75 x 3.30	292	8.8:1	200 @ 4400	285 @ 2200	2b	R
Skyliner		4.00 x 3.30	332	8.9:1	225 @ 4400	325 @ 2200	2b	R
Station Wagons		4.00 x 3.50	352	9.6:1	300 @ 4600	380 @ 2800	4b	P
IMPERIAL	1	4.18 x 3.75	413	10:1	350 @ 4600	.....	4b	P
LARK	1							
Standard		3.56 x 3.25	259.2	8.8:1	180 @ 4500	260 @ 2800	2b	R
Optional		3.56 x 3.25	259.2	8.8:1	195 @ 4500[3]	265 @ 3000	4b	R
LINCOLN	1	4.30 x 3.70	430	10:1	350 @ 4400	490 @ 2800	4b	P
MERCURY	3							
Monterey		4.30 x 3.30	312	8.75:1	235 @ 4600	325 @ 2100	2b	R
Montclair		4.30 x 3.30	383	10:1	322 @ 4600	420 @ 2800	4b	P
Park Lane		4.30 x 3.70	430	10:1	345 @ 4400	480 @ 2800	4b	P
OLDSMOBILE	2							
88		4.00 x 3.64	371	9.75:1	270 @ 4600	390 @ 2400	2b	P
Super 88, 98		4.12 x 3.64	394	9.75:1	315 @ 4600	435 @ 2800	4b	P
PLYMOUTH	2							
Fury		3.91 x 3.31	318	9:1	230	.....	2b	R
Fury (SuperPak)		3.91 x 3.31	318	9:1	260	.....	4b	P
Golden Commando		4.12 x 3.38	361	10:1	305	.....	4b	P
PONTIAC	1							
Catalina, S-Chief		4.06 x 3.75	389	8.6:1	245 @ 4200	392 @ 2000	2b	P
Bonneville		4.06 x 3.75	389	8.6:1	260 @ 4200	400 @ 2800	4b	P
				10:1	280 @ 4400	408 @ 2800	2b	P
				10:1	300 @ 4600	420 @ 2800	4b	P
				10.5:1	315 @ 4600	425 @ 3200	Three (2b)	P
				10.5:1	330 @ 4800[4]	420 @ 2800	4b	P
				10.5:1	345 @ 4800[4]	425 @ 3200	Three (2b)	P
				8.6:1	215 @ 3600[1]	390 @ 2000	2b	R
RAMBLER	1	3.50 x 3.25	250	8.7:1	215 @ 4900	260 @ 2500	4b	R
SILVER HAWK	1	3.56 x 3.25	259.2	8.8:1	180 @ 4500	260 @ 2800	2b	R

[1]With special cam. [2]With dual air cleaners, dual exhausts, and special camshaft, valve springs, and intake manifold. [3]With dual exhausts. [4]With special cam and valve springs.

*Determined by bore and stroke.
†2b = Two-barrel; 4b = Four-barrel; FI = Fuel injection.
§R = Regular; P = Premium.

6s

Make and Model	Bore & Stroke (in.)	Displacement (cu in.)	Compression Ratio	Power, max (bhp)	Torque, max lb-ft	Carburetor
CHEVROLET	3.56 x 3.94	235.5	8.25:1	135 @ 4000	217 @ 2000	Single
DODGE	3.25 x 4.63	230	8:1	135 @ 3600	205 @ 1200	Single
FORD, EDSEL	3.62 x 3.60	223	8.4:1	145 @ 4000	206 @ 2200	Single
LARK, HAWK	3.00 x 4.00	169.6	8.3:1	90 @ 4000	145 @ 2000	Single
PLYMOUTH	3.25 x 4.63	230	8:1	135 @ 3600	205 @ 1200	Single
RAMBLER	3.12 x 4.25	195.6	8.7:1	127 @ 4200	180 @ 1600	Single

ROKIDE* Spray Coatings Protect the Widest Variety of Parts

Some of many possible applications

BAFFLE PLATES
BEARING SURFACES
CRUCIBLES
METAL ROLLS
FEED ROLLS
NOZZLES
PUMP SHAFTS
GAS TURBINE PARTS
DUCT LININGS
EXHAUST PORTS
THERMOCOUPLE TUBES
THERMOCOUPLE WIRE
GENERAL WIRE
MECHANICAL SEALS

Applying ROKIDE Coating to seal

The three types of ROKIDE spray coatings — "A" aluminum oxide, "ZS" zirconium silicate and "Z" zirconium oxide — are hard, adherent, crystalline refractory materials. They can be applied to underlying parts, particularly metals, of a wide variety of shapes and sizes.

Parts on which ROKIDE spray coatings are especially useful are those requiring thermal or electrical insulation . . . refractoriness . . . resistance to wear or corrosion . . . high melting points . . . excellent mechanical strength . . . dimensional stability . . . relative chemical inertness.

The coatings are proving their great protective values in a rapidly growing number of applications. Included are not only the newer fields, such as the manufacture of missiles, ram jets, nuclear reactors, etc. Industry in general, including foundries, metal melting, heat and power plants — plus makers of automotive engines, electrical and electronic products, heavy and light chemicals, ceramics, and pumps — are also safeguarding many different parts with these new Norton developments.

Facilities for applying ROKIDE coatings are maintained at Norton Company, Worcester, Mass., and at its plant 2555 Lafayette Street, Santa Clara, California.

For the latest ROKIDE Bulletin, write to NORTON COMPANY, 770 New Bond St., Worcester, Massachusetts.

NORTON
NEW PRODUCTS
Making better products . . .
to make your products better

NORTON PRODUCTS
Abrasives • Grinding Wheels
Grinding Machines • Refractories

BEHR-MANNING DIVISION
Coated Abrasives • Sharpening Stones
Behr-cat Tapes

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

Circle 413 on Page 19

Photo, courtesy Aluminum Co. of America

There's a "down-to-earth" trend in vehicular uses for structural aluminum. While metals better able to stand the high temperatures of supersonic flight have gradually replaced aluminum in today's aircraft, it is finding new design uses in ground-bound trucks, tanks, trailers. The advantages are significant:

- **Increased payload**
- **Strength and rigidity in a lighter structure**
- **Extended corrosion life**
- **Less downtime for maintenance**

ALUMINUM *Gets Rolling*

INCREASED PAYLOAD and lightweight are key advantages leading to the use of aluminum in the vehicles shown on these pages. Section for section, steel has been the unbeatable metal for strength. But designers are becoming increasingly aware that weight, rather than bulk, is a limiting factor in many mobile structures.

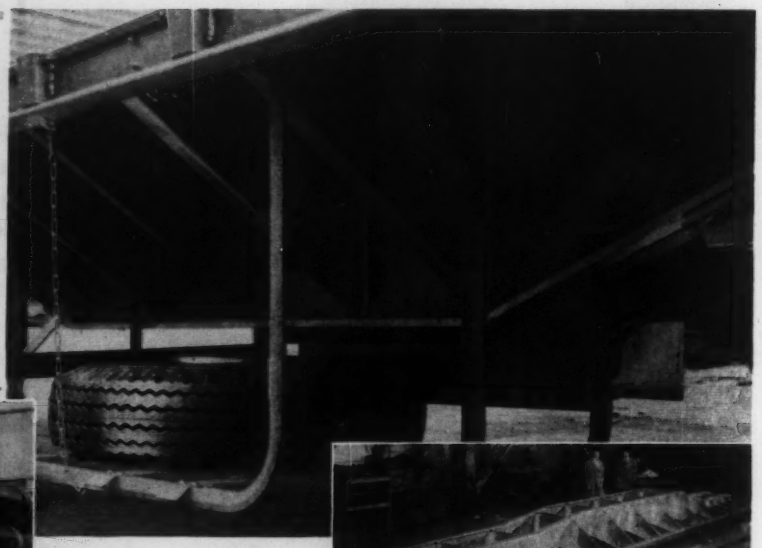
Manufacturers of vehicles are particularly sensitive to structural weight penalties and follow the aircraft industry's lead in searching for light metals to increase payloads. On the basis of strength-to-weight ratio, the high magnesium alloys of aluminum in the weldable 5000 series are superior to steel for many uses. Hardness and tensile strength are not substantially lower, and although aluminum's modulus of elasticity is about one-third that of steel, so is its density.

New fabricating techniques, including inert-gas arc-welding, are playing their part in expanding aluminum's horizon. Corrosion resistance, of course, is a long-standing attribute that makes aluminum even more advantageous in vehicular applications.

An incident reported by Kaiser

Aluminum demonstrates the ruggedness of aluminum vehicles: A 30-foot aluminum flatbed trailer had been loaded with a 45,000-lb cargo, but the fifth wheel was not attached. When the tractor drove away, the trailer crashed to the ground with the 22½-ton load still aboard. The only damage was a few simply repaired broken welds in the neck of the trailer.

Photo, courtesy Kaiser Aluminum and Chemical Corp.



Mountain Climber Saves Weight

Welded seams on lightened outrigger-and girder frame members are shown in this detail photo of a flatbed trailer built by Trailmobile, Berkeley, Calif., for Pacific Mountain Express. Careful design with 5083 aluminum alloy made possible radical weight savings, yet produced a trailer with greater strength than an earlier aluminum model (inset photo). Pipe-carrying truck, which uses the standard aluminum bed, also has aluminum wheels.

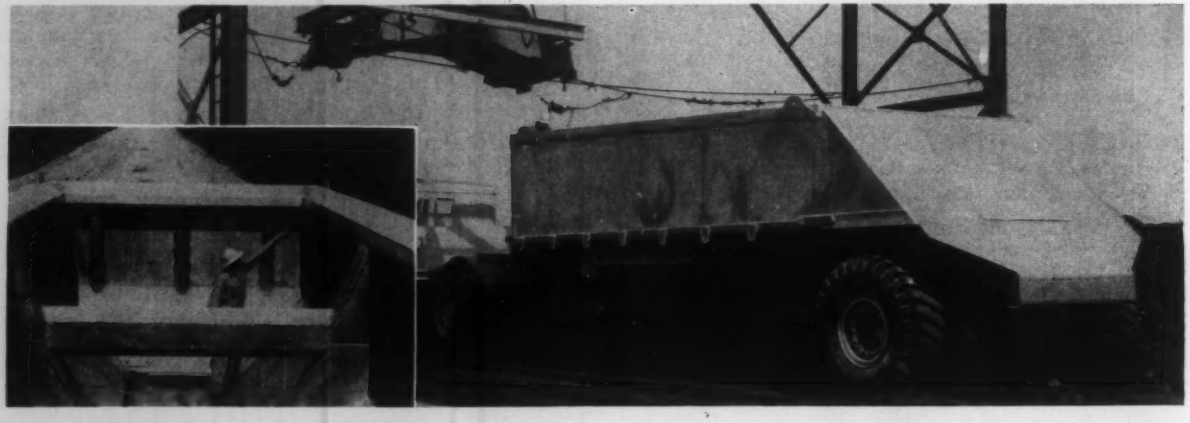
Bottom-Dump Trailer Earns More Money

An extra $1.25 per yard-hour is earned by this aluminum bottom-dump trailer built by Schetky Equipment Corp., Portland, Oregon. Because its weight is little more than half the weight of a similar steel vehicle, it can carry an additional 2320 lb of payload. Unit is constructed of Kaiser alloy 5086 sheet and plate.

Sixty Tons of Coal Waits for Customer

Coal from this mammoth cross-country coal hauler is destined to power a new aluminum smelter belonging to Aluminum Co. of America. Inset shows details of the 37 ft by 11 ft body. Using 5456 alloy gave a weight saving of 10,000 pounds. Builder is General American Transportation Co., Chicago, Ill.

Photo, courtesy Aluminum Co. of America



He's been working on the railroad . . .

the TRS rivet man found a $7000 saving in A. C. Gilbert's train transformers

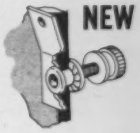
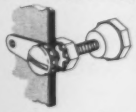
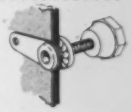
You needn't be rich to give your boy a fine American Flyer train because Gilbert never misses a possibility for reducing costs.

For example, they challenged a TRS sales engineer to find ways to save on transformer assemblies. He uncovered *two* . . . worth $7000 on a year's production.

Invite the TRS man to check over your assemblies. You'll find that he is more than a salesman . . . that he has the viewpoint of a manufacturing engineer. Chances are he can contribute practical ideas for making your assemblies simpler, faster, better.

Of course he sells rivets. And he can give you sensible reasons why TRS Tubular Rivets are more reliable in essential qualities and uniformity. Ask to see the TRS Quality Control Album . . . one significant result of a five-year modernization of this pioneer company. Modernization of people, policies, production and service facilities. *You'll like to do business with the new TRS . . . we'll make sure of it.*

SEE WHAT THE TRS MAN FOUND

OLD	NEW
	
Found: Contact fastener and binding post. Expensive brass stud machined from hex stock, 8/32 thread, and brass nut. Hex must be recessed in plastic to stop rotation.	**Suggested:** Low-cost 10/32 threaded collar rivet and nut of steel. Automatically clinched to hold firm without hex or recess. Underwriters' ok'd change to steel if 10/32 thread.
	
Found: Five-piece lug fastener and binding post . . . expensive 8/32 brass screw and hex lock nut, 2 lock washers, brass terminal nut.	**Suggested:** Low-cost threaded steel collar rivet and steel nut, 10/32 thread.

Don't Buy Riveting Machines until you learn how the TRS **PAR** *process revolutionizes riveting*

TRS®

TUBULAR RIVET & STUD COMPANY

QUINCY 70, MASSACHUSETTS • Midwest Office & Warehouse in Chicago. Branches: Atlanta, Buffalo, Charlotte, Cleveland, Dallas, Detroit, Hartford, Indianapolis, Los Angeles, New York City, Philadelphia, Seattle, Springfield, St. Louis. See "Yellow Pages" for phone numbers.

If it's a Tubular Rivet TRS makes it . . . and Better

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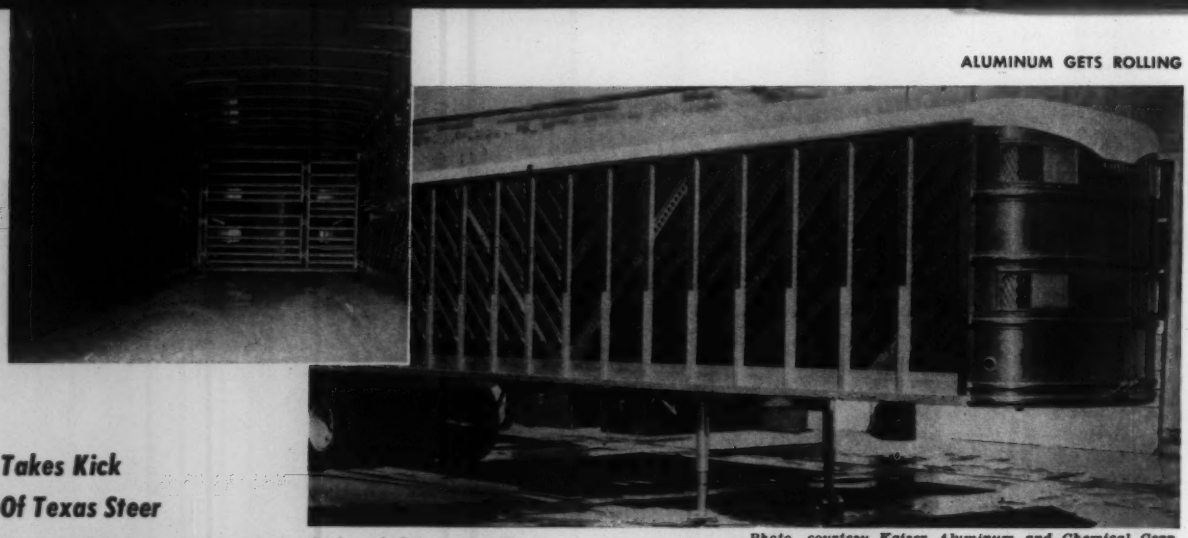
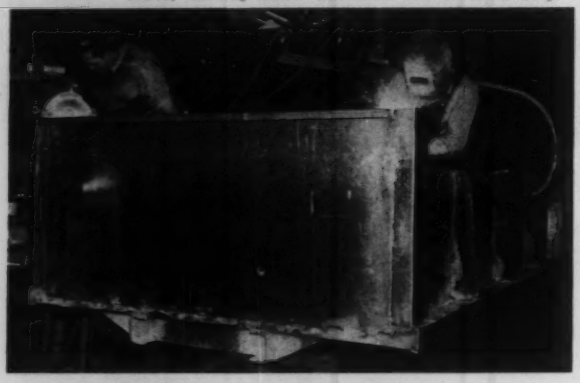


Takes Kick Of Texas Steer

Dent resistance to withstand the kicks of full-grown Texas steers is designed into the diagonal side slats of this livestock trailer. The unique construction, makes possible a body of almost any usable length without "beefing up" side frames. Stock arrives in better condition because of aluminum's reflective insulation and ventilation from diagonal slots which act as air scoops. The 6061 aluminum alloy resists attacks of animal acids better than steel or wood; smooth finish of metal and open design make trailer easy to clean. Trailer is built by Wilson Trailer Co., Sioux City, Iowa.

Photo, courtesy Kaiser Aluminum and Chemical Corp.



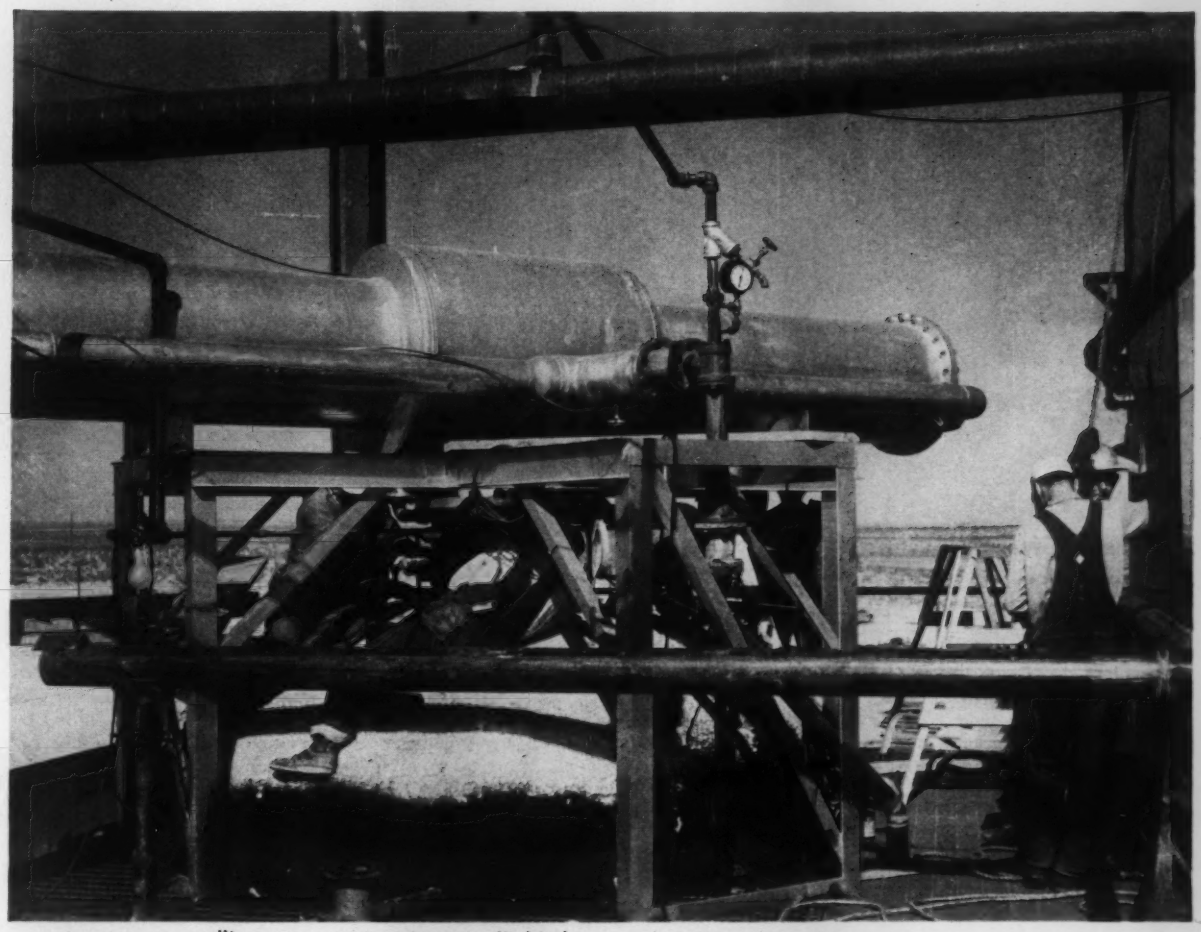
Arc Welding Speeds Fabrication

Inert-gas arc welding on aluminum needs no special equipment and costs about the same as on steel. Alloys in the 5000 series can be resistance welded to aircraft standards. Gas welding and arc welding with flux-coated electrodes are not recommended.

Official U. S. Army Photo

Aluminum Armor Protects Troops

Ballistic protection of 5083 aluminum-alloy armor on aluminum personnel carrier (right) equals that of steel vehicle (left). Light weight is important for air transportation. Vehicles were built for Army by Food Machinery and Chemical Corp., Ordnance Div., San Jose, Calif.



Erecting a crystallizer at a potash refinery in Carlsbad, N. M. operated by the U. S. Potash Co., a division of U. S. Borax & Chemical Corp. This is one of seven crystallizers that were shop- and field-fabricated, then field-assembled by welding. They were not stress-relieved or heat-treated. There has been no stress-corrosion cracking in the nine months these units have been in service at the potash refinery.

NEW Ampco Metal Grade 8 stops stress-corrosion cracking!

Important changes have been made in Ampco Metal Grade 8! It's *entirely new*—and completely obsoletes old ideas about fabricating copper-base alloy equipment to handle steam and corrosive media at elevated temperatures.

Now, with new, patented Ampco Metal Grade 8, you can . . .

1. Field-fabricate *without stress-relieving!*
2. Make field repairs, changes, and alterations *without heat treatments!*
3. Readily weld with any electric welding process! A. No pre-heat. B. No post-heat. C. No hot-short cracking!

At one major oil refinery, field-assembled piping of Ampco Metal Grade 8 has handled hot sulphuric-acid sludge for a year and a half without stress-corrosion cracking. Driers in a paper mill have handled 350° F steam at 125-lbs. pressure for more than a year without stress-corrosion cracking.

Let us prove it to you. Talk to your Ampco field engineer. Or write for details. *Ampco Metal, Inc., Dept. 31K, Milwaukee 46, Wis. West Coast Plant: Burbank, Calif.—Southwest plant: Garland (Dallas County), Texas.*

TS-1

AMPCO®

AMPCO

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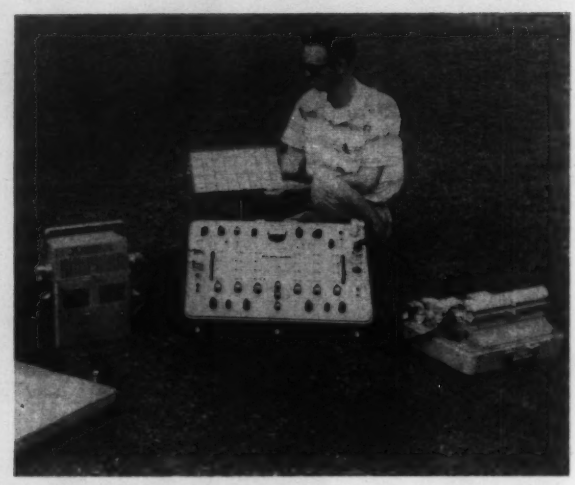
Planimeter Gives Digital Readout

Area readout to five digits is available from a new planimeter designed for strip-chart data. Using a manual reset digital counter, the instrument offers a choice of linear or square-root summations by the change of a cam. The planimeter accommodates 4-in. wide rectilinear charts which are fed through at any speed up to 12 chart hours per minute. Chart feed is controlled by a foot-operated rheostat; pointer tracking is done manually. The instrument was developed by Fischer & Porter Co., Hatboro, Pa.



Sun-Powered Seismograph

Power demands of the first transistorized seismic amplifier are low enough to permit use of an 8 x 15-in. silicon solar converter for battery charging. The 24-channel seismograph is contained in two cases weighing 100 lb. Output of the experimental solar charging unit is 250 milliamp at 12 v. It needs 10 hr exposure to sunlight to maintain the 12-v battery in normal operating condition. Developed by Texas Instruments Inc., the equipment will aid seismic exploration crews in searching for oil and minerals.

Tiny Phenolic Balloons Make Structural Foam

Air-Drying Plastic Mix Stiffens Sailboat Topsides

NEW YORK—A lightweight structural material—made of tiny Bakelite "Microballoons" mixed with a catalyzed liquid plastic binder—has found one of its first production-line uses as a stiffener for sailboat decks. The material, called a "syntactic foam," is sandwiched between the underside of the molded deck and a glass-fiber reinforcing layer. Developed by the Cape Cod Shipbuilding Co., Wareham, Mass., the technique eliminates deck ripples caused by shrinkage of conventional carlins and deck beams.

Microballoons, a product of Standard Oil Co. of Ohio, are microscopic Bakelite spheres (0.0017 in. diam.) which look like fine, brown-colored flour. The syntactic foam, a combination of spheres mixed with a plastic — either polyester or epoxy resin — is easily applied, sets up rapidly, and cures completely within four hours at room temperature.

Both Bakelite epoxy resins, made by Union Carbide, and polyester

First step after forming sailboat deck and "cuddy" unit (plastic reinforced with glass fiber) is to cut reinforcing flat panels for foredeck, cuddy top, and stern deck. After shaping, these panels are troweled with an 80 per cent (by weight) of Microballoons and 20 per cent binder. They are then pressed into place and rolled flat. Excess filler is scraped away with a wooden spatula. Hull and deck can then be assembled before either is completely dry thus saving up to 50 per cent in production time on a boat. The new sections add to the boats' buoyancy since they are lighter than water.

HERE'S WHY P&B's PR POWER RELAY IS PREFERRED

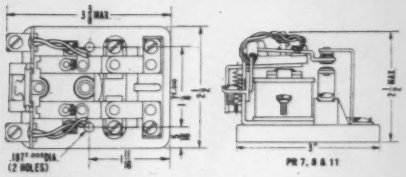
for high current/voltage switching

HEAVY DUTY construction means long-term dependability when switching up to 20 amperes (double break contacts). Here is a ruggedly built relay, packed with high quality features, yet economically priced.

The PR's full floating movable contact carrier, for example, provides excellent contact pressure and ample wipe for self-cleaning contact action. The coil is centrifugally impregnated with top-grade varnish to eliminate moisture traps.

Contact arrangements up to DPDT are available. The PR has been adapted for printed circuitry and heavy duty plug-in applications.

All standard AC actuated PR relays may carry the UL and Canadian Standards Association seals of approval. Write or call for complete information.



GENERAL SPECIFICATIONS:
Breakdown Voltage: 1500 volts rms min. between all elements and ground.
Ambient Temperature: DC: —55° to +85°C. AC: —55° to +55°C.
Terminals: Heavy duty screw type. Standard printed circuit pins or plug-in on request.
Enclosures: PR dust cover.

CONTACTS:
Arrangements: Up to 2 Form C (DPDT).
Material: 5/16" dia. silver or silver cadmium oxide. (Others available)
Load: Single break: 15 amps; Double break: 20 amps at 115 volts 60 cycle AC resistive.

AUXILIARY CONTACTS:
Arrangements: 1 Form A, B or C.
Material: 3/16" diameter silver
Rating: 5 amps at 115 volts 60 cycle AC resistive.

COILS:
Resistance: 64,000 ohms maximum.
Power: 1.8 watts DC; 9.8 volt-amps AC.
Duty: Continuous AC or DC (DC coils will withstand 10 watts at 25°C).
Insulation: Centrifugally impregnated with high quality varnish.
Mountings: 2 holes .187" diameter 1⅞" o.c.

PR Relays Approved By Underwriters' Laboratories and Canadian Standards Association

Type	Contact Arrangement*	Type	Contact Arrangement*
PR1AY	SPST-NO	PR5AY	SPDT
PR2AY	SPST-NC	PR7AY	DPST-NO
PR3AY	SPDT-NO-DM	PR8AY	DPST-NC
PR4AY	SPDT-NC-DB	PR11AY	DPDT

These relays are available in any of the following operating voltages: 6, 12, 24, 48, 115, 208, 230, or 440 volts 50/60 cycles AC.
The contacts are rated at: 13 amps, 115 volts AC. 6.5 amps, 230 volts AC. 1 hp for 115 or 230 volt AC motors.
Any relays deviating electrically or physically from these standard models will not carry U/L or CSA approval.
*Read: NO normally open, NC normally closed, DB double break, DM double make.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

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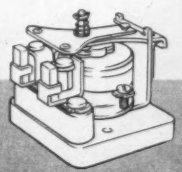
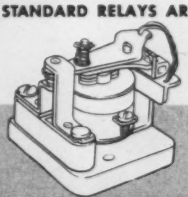
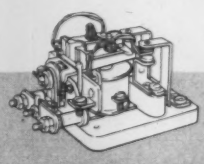


PR RELAY WITH MAGNETIC BLOW-OUTS
Models PR3 and PR7 can be supplied with alnico magnets to suppress arcs on DC loads over 1200 watts.



SINGLE POLE DOUBLE THROW VERSION
PR 5 (SPDT) has all the heavy-duty features of other models in this series.



PR WITH AUXILIARY CONTACTS
All PR models can be equipped with auxilliary contacts in 1 Form A, B, or C arrangements.

POTTER & BRUMFIELD INC.
PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

resins are finding use in the syntactic foams. In general, a given proportion of phenolic spheres to liquid resin gives approximately the same density of foam with the different resin binders. However, Union Carbide claims a significantly higher strength for the epoxy-resin based mixture.

Iron Replaces Bronze In Low-Cost Sintered Bearing

DETROIT—Cost of materials is reduced by a factor of four over previous bearings by use of iron powder in a new sintered bearing. Designed for economy in moderate-stress applications, the bearing is limited to noncorrosive locations.

Reciprocal and oscillating operation is acceptable for the bearing since it can run a limited time without lubrication and can thus endure the break in protective oil film inherent in a reversal. Called Iron Oilite 212, it is made by Amplex Div., Chrysler Corp., Detroit. Characteristics of the new sintered bearing, compared to those of a standard sintered-bronze bearing, are:

Low-cost sintered-iron bearing has operating characteristics comparable to higher priced copper and bronze bearings. Typical applications are fractional horsepower motors, power tools, instruments, communication equipment.

	Iron	Bronze
Oil absorption (per cent)	18-23	18-23
Tensile strength (psi)	10,000	18,000
Compressive yield point (psi)	9,500	20,000
Specific gravity	6.1-6.5	6.4-6.7

New Steels Compete With Light Metals

Outstanding Strength-Weight Ratios Achieved, Claims Ford

DEARBORN, MICH.—Tensile strengths to 400,000 psi, high enough to compare steel with the best titanium alloys on a strength-weight ratio basis, are announced for steels going through a new treatment at the Ford Scientific Laboratory. The process consists of plastically deforming Austenitic steels above the Martensite temperature and then transforming them to Martensite. A remarkable feature is the high ductility possessed by the untempered Martensite. Conventional steels in similar condition are notoriously brittle.

At low temperatures, steel treated by the new process seems to retain its desirable physical properties. Experimenters say that there is little change in basic characteristics in temperatures as low as that of liquid nitrogen (− 385 F). Brittleness at low temperatures is as much a problem to designers as is low

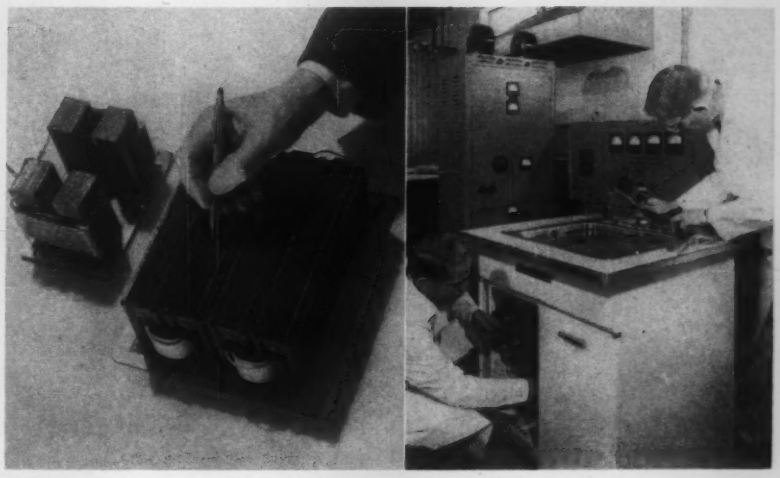
strength at elevated temperatures.

Basing estimates on the fact that the fatigue limit of high-strength steels is usually about half the tensile strength, Ford metallurgists predict that steels undergoing the new process should have a fatigue strength of around 200,000 psi, an improvement of 30 per cent over present steels.

No Grease Jobs for '68 Cars

Engineering advances since 1950 have eliminated more than half of the grease fittings on new cars and the other half will be gone by 1968, according to William M. Drout, manager of marketing economics for Esso Standard Oil Co.

Automobile manufacturers are working hard for the sales advantage of being first to develop the greaseless car, according to Drout, and the problem will be solved in ten years at the most, with some conservative experts predicting a solution in five years. Development of low-cost, long-life sealed bearings would solve the problem.



Ultrasonics: Next, The Kitchen Sink

More applications for ultrasonics are promised with a new transducer developed by Westinghouse. The device is said to combine efficiency of the electrostrictive transducer with general ruggedness and high-temperature, high-intensity capabilities of the conventional magnetostrictive unit. It differs from others of its type in the mode of vibration emitted from the transducer radiation plate. In a conventional transducer, the plate vibrates in a wavelike manner due to spacing of the individual laminations, far left. In the Westinghouse unit, laminations are spaced in a latticework arrangement across the plate and work in unison to provide a single, piston-like action. The transducer is suitable for almost all applications involving irradiation of a liquid bath, and is already being used in several new industrial applications. Sink-mounted ultrasonic dishwashers are also a possibility, according to Westinghouse.

FROM END TO END . . . INSIDE AND OUT . . . MADE RIGHT IN OUR OWN PLANT
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TITEFLEX, INC.
Hendee Street,
Springfield, Mass.
Springfield
"400"
There is nothing like Teflon flexible hose for tough applications. Now, for the first time, you get "finger flexibility" in large diameters up to four inches with Springfield "400" . . . an exclusive new development by Titeflex. Short bend radius, long lengths, plus "Zero Motion Braid" make Titeflex Springfield "400" the big news in Teflon hose. Write for complete information, Bulletin 400.

"One of the most important areas of mechanical design—high-speed mechanisms—is one of the most neglected," according to IBM's F. E. Fisher, left. He told Conference members that new high-speed measurement techniques are available and easy to use. William G. Hyzer, center, consulting research engineer, demonstrated uses of the high-speed movie camera—a valuable tool in micromotion analysis. Distinguished German kinematician Rudolf Beyer, right, surveyed space mechanisms (3-D mechanisms). He predicts their increased use based on recent research by Russian, German, and American scientists.

Mechanisms Conference Draws 225 Engineers

Design engineers from top U. S. industries attended the Fifth Mechanisms Conference at Purdue University, October 13 and 14. Representatives from 16 universities were also in attendance, including Dr. Rudolf Beyer, distinguished German kinematician from Technical University, Munich, and J. Hirschhorn, New South Wales University of Technology, Sydney, Australia.

Co-sponsored by MACHINE DESIGN and Purdue's School of Mechanical Engineering, the Conference is regarded as the fountainhead of mechanism design in this country. It also draws international recognition — Prof. J. Denavit, Northwestern University, gave Conference members a brief rundown on Russian and East German mechanism conferences, and reported that the Purdue meeting is well recognized on the continent.

Most of the technical papers presented dealt with new or unusual techniques in kinematics. Some were pioneering efforts, offering aid principally to the professionals in the area. Others were quite practical and directly applicable in design.

The engineer's most valuable tool will be a thorough knowledge of basic and applied sciences—to enable quick translation of new ideas to practical applications, according to J. F. Young, left, manager of GE's General Engineering Laboratory. A. J. Borst, Bell Helicopters, R. L. Droke, IBM, and Prof. G. W. Bergren, Purdue University, examine William Hyzer's high-speed movie camera.

3rd MARS Design Contest

HACKENSACK, N. J. – The MARS Outstanding Design Contests have uncovered numerous interesting designs which might otherwise never have been brought before technical audiences. They have attracted such wide interest that MARS Pencils is sponsoring another contest in 1959.

Carl J. Rauschenberger, Anaheim, Calif., one of the winners in the 1958 MARS Contest.

If you are an engineer, architect or student, the MARS contest offers you a "showcase." It provides you with a valuable opportunity to have projects you designed shown in leading magazines where they will be seen by the men in your profession.

$100 Awards

Send in your designs. Every winner will receive $100; winning entries will be reproduced in the wide list of technical publications in which the MARS Outstanding Design Series appears. There are no strings attached. You will be given full credit. All future rights to the design remain with you. You can reproduce it later wherever you like and sell or dispose of it as you wish.

The subject can be almost anything — aviation, space travel, autos, trains, buildings, engineering structures, household items, tools, machines, business equipment, etc. Projects will be selected on the basis of appeal to design-minded readers, broad interest, attractive presentation. Do not submit a design that is in production. The project, in fact, does not need to have been planned for actual execution. It should, however, be either feasible at present or a logical extension of current trends. It cannot be unrealistic or involve purely hypothetical alterations of natural laws.

The sooner you send in your entry, the greater the chance of its selection.

It is Simple To Submit a Design For Mars Outstanding Design Series

Just mail in an inexpensive photostat or photocopy of the subject – one you can spare, since it cannot be returned – and a brief description.

If your entry is accepted, we will ask for a clear illustration of your design in order to prepare a sharp rendering, or photograph suitable for reproduction. Your material will then be returned to you.

Send your entry to:

J.S. STAEDTLER, INC.
Hackensack, New Jersey

Circle 418 on Page 19→

Here are some of the fine MARS drafting products, imported from West Germany, made to meet the highest professional standards. ● Bright-hued LUMOCHROM pencils come in 24 colors for color-coded drafting and perfect reproduction. ● LUMOGRAPH graphite drawing pencils come in 19 degrees. Some degrees available with erasers, some with special chisel points. ● TECHNICO lead holders for color and black graphite drawing have new sure-hold finger grips, with degree markings for quick identification. Also available with clips for pocket use. ● NON-PRINT pencil and leads let you make notes and sketches that will not reproduce. ● Pencil sharpeners come in STANDARD and "DRAFTSMAN" models; latter with adjustable point length feature.

your brain's best friends

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Like thousands of your colleagues, you will find the shortest distance between idea and execution in MARS drafting products. They are your brain's best friends.

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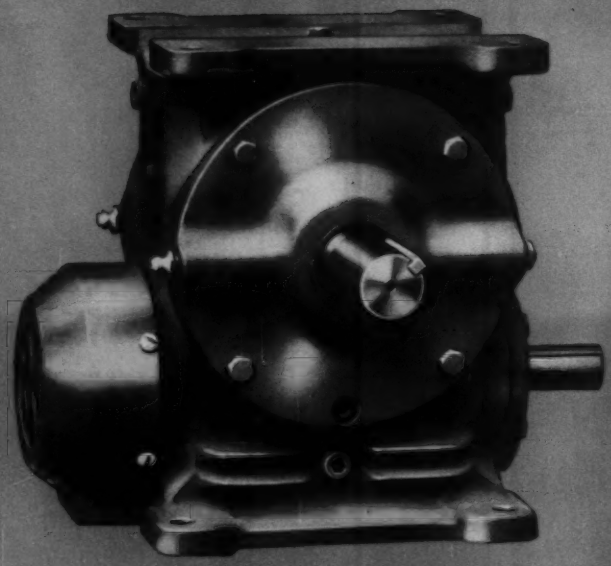
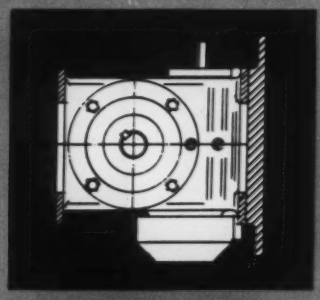
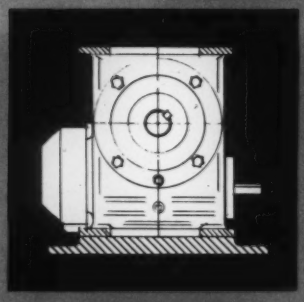
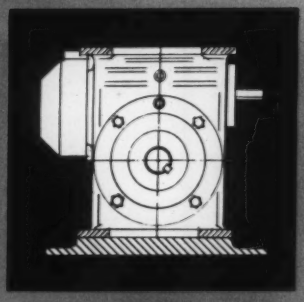
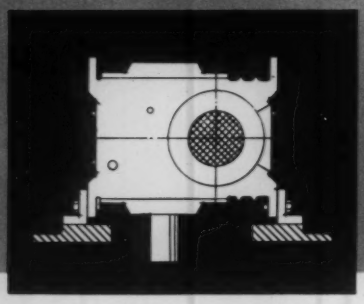
adapt to any mounting requirement

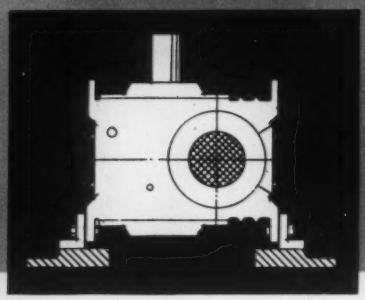


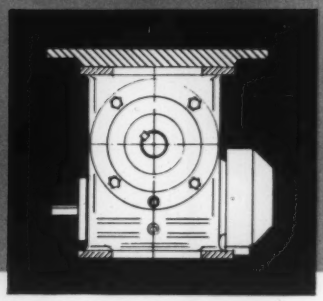












More Horsepower per Dollar

- *Fan cooled*
- *Involute helicoid thread form has heaviest load capacity of any type of worm gear*
- *Sturdy cast iron case and tapered roller bearings ensure maximum load capacity*
- *Gear shafts are heat treated alloy steel*
- *Worm and worm shaft is a single piece of nickel alloy steel*
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- *Finest American craftsmanship*

Now De Laval offers you a complete new line of versatile worm gear speed reducers. These reducers are designed for heavy duty industrial work and continuous running under demanding service. The units may be mounted in any position.

For further information write for Bulletin 5018

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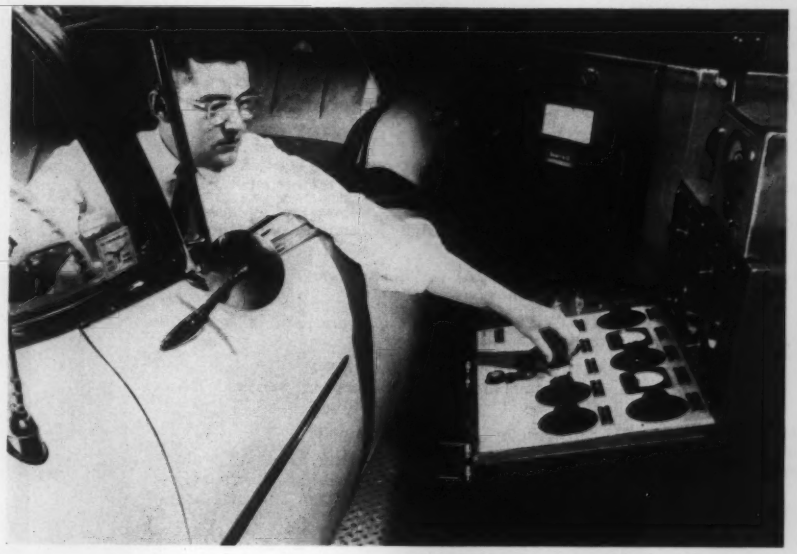

Ersatz Inertia

Electrically-simulated inertia replaces unwieldy flywheels on chassis test stands at GM's Oldsmobile Div. With the new dynamometer control system, the operator merely adjusts a potentiometer to simulate any desired car weight. Stepless control gives a much finer degree of accuracy than was possible with the old 200-lb inertia discs, right. The system was designed and built by General Electric's Industry Control Dept., Roanoke, Va.

Designer Strikes Back at Car-Style Critics

But Admits That Some Criticism is Warranted

Do the people, i.e., customers, set styling standards for the automotive industry, or do today's cars pour out of Detroit in such quantity and uniformity of size, shape, and decoration, that the people are simply outnumbered? And if industry does set the standards, is it actually the stylist who is responsible, or do sales departments and top management modify the original designs to produce the car on the street? These and other questions are subjects of an entertaining and decidedly frank analysis of car styles by a prominent industrial designer.

Open Season on Stylists

Speaking before a recent meeting of the American Society of Body Engineers, Carl Sundberg, president, Sundberg-Ferar Inc., declared, "Panning the American automobile has become a pastime that threatens to replace baseball as a national sport." He described the auto stylist as being a target for publicity-seeking industrial designers and smart-aleck writers and design critics, professional and amateur, who want to establish their good taste by sneering at auto styling. In fact, says Sundberg, the auto stylist has become the most maligned man in the design profession.

The Blame: Top Brass?

Mr. Sundberg personally polled a number of his fellow designers, all leading members of independent industrial-design organizations, and presented a roundup of their opinions for the benefit of the auto

(Advertisement)

STRENGTH WOUND INTO IT

Research has proved that a light flexible wire with several alternate layers of wire wound around it produces a cable more flexible than a single wire of the same diameter and is capable of carrying a much higher torque. Flexible shafts are composed of this type cable plus a flexible casing which provides protection from dirt, grime, or grease.

There are two types of flexible cables used in flexible shaft assemblies. One is the power drive flexible cable in which the wires are wound in alternate direction. The outer layer of wire determines the direction rotation and is made to tighten when in use to add strength and form a practically unbreakable unit. The main advantage of the power drive flexible cable is its simplicity of alignment, as it is capable of transmitting power over, under, and around any obstacle between the drive and the driven elements.

Power drive cable with wires partly unwound to show construction of the cable.

Section of remote control cable showing superimposed layers of wire wound in opposite direction.

The other type flexible cable is the remote control flexible cable which due to being constructed of smaller gauged wires than the power drive cable, and wound by a special process, provides for both rotation and reciprocation such as the opening and closing of a valve.

Both of these flexible shafts may function in a continuous or intermittent operation with a minimum amount of vibration. They not only offer long lasting strength but also economies in cost, time and space.

Send for further details on how flexible shafting may be easily and economically incorporated into your design.

Write F. W. Stewart Corporation, Dept. 5, 4311-13 Ravenswood Avenue, Chicago 13, Illinois.

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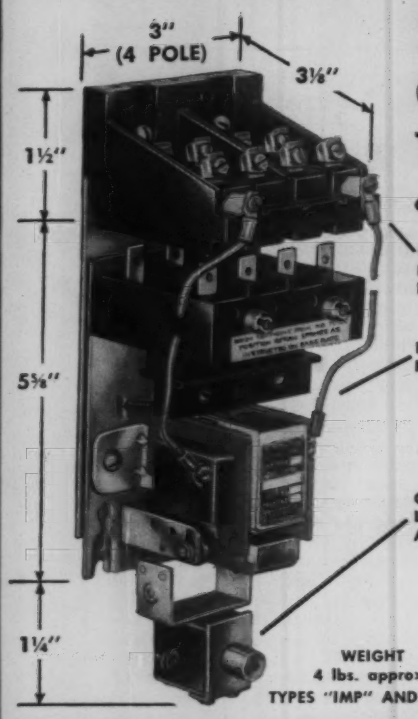

HEAVY DUTY RELAYS GREATEST Control Versatility Ever Offered

600 VOLTS AC • 10 and 15 AMPS • 2, 3, 4, 6 or 8 POLES

- **RUGGED and RELIABLE . . .** with exceptional electrical and mechanical life. Simple construction for easy maintenance.
- **OPTIONAL PLUG-IN RECEPTACLE . . .** allows fast replacement of relay *without* disturbing wiring. Minimizes down-time on high-output machines.
- **FAST, EASY COIL REMOVAL . . .** just remove 2 screws, swing coil to front and lift out entire assembly.
- **SIMPLE CONTACT CONVERSION . . .** from normally-open to normally-closed. No tools needed.
- **MOST VERSATILE LATCHING ATTACHMENT . . .** exclusive with A-H. Only attachment that converts in the field from "latch-in" to "latch-out" or "latch in-and-out."
- **AVAILABLE . . .** with AC or DC holding coils.

For free copy of the 8-page Heavy Duty Relay Catalog Section, write to The Arrow-Hart & Hegeman Electric Co., Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

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ARROW AH HART

audience. A summary of comments:

• "It has always been my belief that if Detroit designers, who according to my definition are expert designers, are only left to their own resources instead of being beaten about the ears by frightened sales engineers, a good design might well be forthcoming. There is no question in my mind that some excellent forms are developed in clay, and this to me is often a true design expression. It is only when the lily is gilded with chrome and strips of plastic that the form is distorted and ruined."

• "It is ironical that cars can hope for little more than faint praise from a professional group that most certainly includes the automobile designer himself!"

• "Detroit is making a desperate attempt to retrace its steps out of the chrome jungle and rebuild the desire of the consumer for the product offered in the market place. We see a slight change in the philosophy of styling, but have not yet seen even the slightest indication that the concept of design for a really improved unit of transportation has filtered up to the levels of top brass who must make the ultimate decisions in the automobile industry."

• "Since there have been some improvements in the styling of the '59 lines, and many more changes which have not really achieved any mark of improvement, there are those who will point to increased sales as an indication that the cars are better. Detroit had best remember that the failure of the consumer to buy new cars in 1958 created a replacement market that will certainly benefit sales figures in '59, but will not honestly be a nod of approval from the consumer toward Detroit."

• "Because all cars are now competitive in size, distinction and identity are even more difficult to obtain. The size step-up which determined price in the past is no longer well defined. Can the auto industry continue to obtain merchandising differences between price points by means of styling only? I think not. Not so long ago, the low-priced cars looked the part. Now the attempt is to make them look as luxurious as their higher priced brothers. True, there are some mechanical and interior advantages in the higher priced models. But styling, which should be an aid to dramatize the difference, tends to do just the opposite. Maybe this is the way to go, for it increases the volume of sales of the so-called low priced cars—but only at the expense of the middle price bracket."

The Road Back

The rules of good design are just as clearly defined as those of good engineering, concludes Mr. Sundberg, and "The well-trained designer is the best man to apply these rules and should be allowed to do so without interference from well-meaning executives or eager sales managers.

"Only good design can succeed, because, believe it or not, most of the people, rich and poor, have much better taste than they are given credit for."

Machine Design Appoints Assistant Editor

CLEVELAND — Theodore M. Leach has joined the staff of MACHINE DESIGN as an assistant editor.

Mr. Leach earned a bachelor of arts degree from Capital University, Columbus, Ohio, then received his

Theodore M. Leach

engineering training at Hillyer College in Hartford, Conn., while he was employed at Pratt & Whitney Aircraft Co. there. He became a designer of components for aircraft engines at Pratt & Whitney. Just prior to joining MACHINE DESIGN, he was a design engineer at Arrow-Hart & Hegeman Electric Co. in Hartford.

Mr. Leach's present assignment is preparation of material for the Engineering News section.

Meetings

AND EXPOSITIONS

Nov. 30-Dec. 5—

American Society of Mechanical Engineers. Annual Meeting to be held at the Statler Hilton and Sheraton-McAlpin Hotels, New York. Additional information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

Dec. 1-3—

American Society of Refrigerating Engineers. Semiannual Meeting to be held at the Roosevelt Hotel, New Orleans. Additional information can be obtained from headquarters of ASRE, 234 Fifth Ave., New York 1, N. Y.

Dec. 1-5—

23rd National Exposition of Power and Mechanical Engineering to be held at the Coliseum, New York. Exposition is under the auspices of ASME. Further information is available from International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Dec. 2-4—

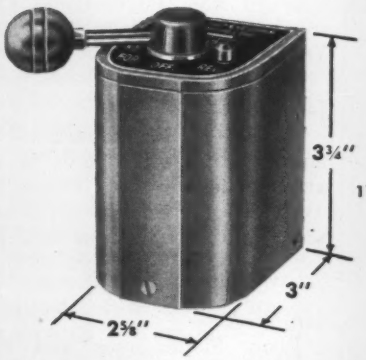
Electronic Industries Association. Conference on Reliable Electrical Connections to be held at the Statler Hilton Hotel, Dallas. Further information is available from Mr. R. George Roesch, 1068 S. Clinton St., Syracuse 4, N. Y.

Dec. 3-5—

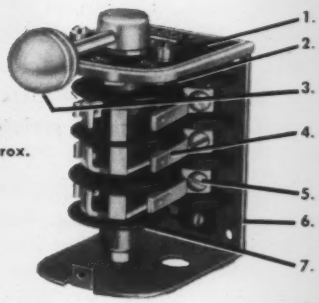
Eastern Joint Computer Conference and Exhibit to be held at the Bellevue-Stratford Hotel, Philadel-

MOTOR CONTROLS

Reliable – Low-Cost – Durable
The NEW Type "DR" Reversing Drum Switch



WEIGHT
1½ lbs. approx.



1. Easy-To-Read Name Plate.
2. Easy Conversion from Maintained to Momentary Contact.
3. Self-Centering Handle with Positive Spring Action.
4. Heavy, Silver Plated Contacts for Long Electrical Life. Fully Visible, Easily Replaceable.
5. Easy-To-Wire Terminals.
6. Simple, Rugged Construction for Long Mechanical Life.
7. Insulation Barriers Between Contacts Prevent Flashovers.

CATALOG NO. DR-001: Size 00, has 3 poles arranged to break 2 lines to motor. Rated 1 hp maximum at 115 volts ac, single phase . . . or 220 volts ac, polyphase.

CATALOG NO. DR-02: Size 0, has contacts arranged to break 3 lines to motor. Rated 1 hp maximum at 115 volts ac, single phase to 2 hp maximum at 440-550 volts ac, polyphase.

For complete information on this new Type "DR" Reversing Drum Switch, write to The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

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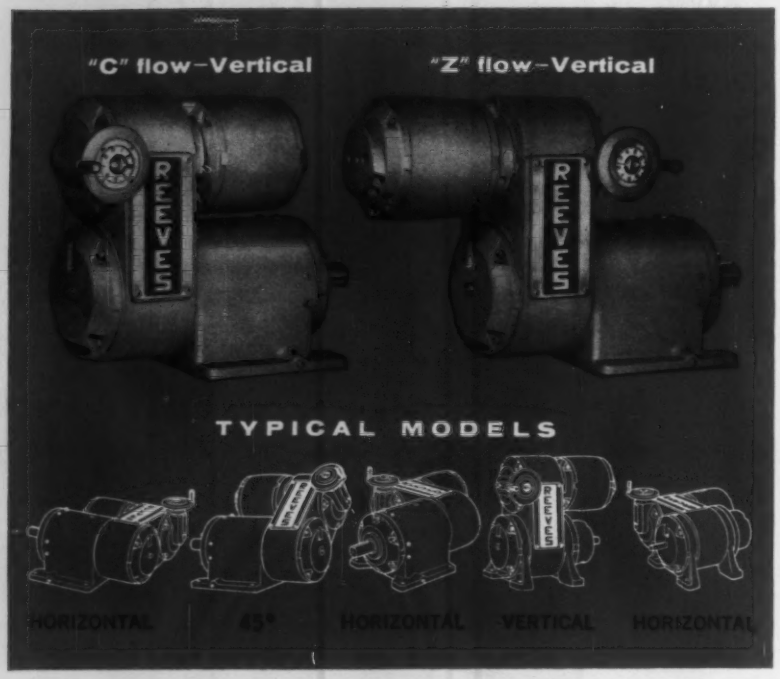
NEW **REEVES**®

*Sizes 200-300-400 Vari-Speed MOTODRIVES**

* *200-300-400 Sizes, 1 through 10 hp.; full line, ¼ through 40 hp.*



The flexible design of these compact new REEVES variable speed power packages permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements. All models are available in both "C" flow and "Z" flow styles.

New increased capacity is built in the reducers—single, double or triple stages...new disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Complete information on all phases of the versatile 200-300-400 sizes Vari-Speed Motodrives is given in new Catalog. Write for your free copy today—Dept. H32e-M571.

REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

phia. Sponsors are American Institute of Electrical Engineers, Institute of Radio Engineers, and Association for Computing Machinery. Further information can be obtained from conference chairman John M. Broomall, Burroughs Corp., Research Center, Paoli, Pa.

Dec. 8-10—

American Nuclear Society. Annual Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information can be obtained from the society's Detroit headquarters, 2000 Second Ave., Detroit 26, Mich.

Jan. 12-14—

Fifth National Symposium on Reliability and Quality Control in Electronics to be held at the Bellevue-Stratford Hotel, Philadelphia. Sponsors are American Institute of Electrical Engineers, American Society for Quality Control, Electronic Industries Association, and Institute of Radio Engineers. Additional information can be obtained from E. K. Morse, Aeronautical Radio Inc., 1700 K St. N.W., Washington, D. C.

Jan. 26-29—

Fourteenth International Heating & Air-Conditioning Exposition to be held at Convention Hall, Philadelphia. Exposition is to be held under the auspices of the American Society of Heating and Air-Conditioning Engineers, and the society's 64th annual meeting will be held concurrently. Further information can be obtained from International Exposition Co., 480 Lexington Ave., New York 17, N. Y.

Jan. 26-29—

Institute of the Aeronautical Sciences. Annual Meeting to be held at the Sheraton-Astor Hotel, New York. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 26-29—

Plant Maintenance and Engineering Show to be held at Public Auditorium, Cleveland. Additional information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

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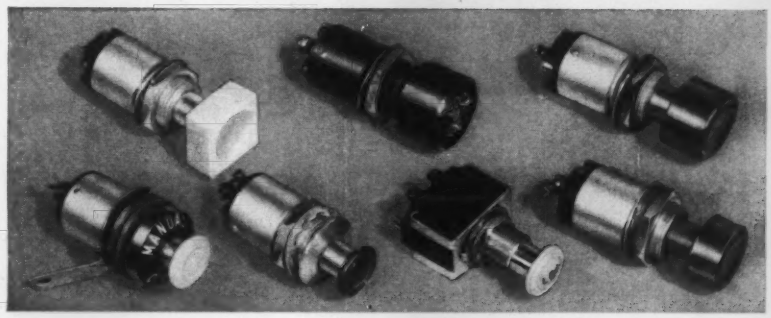
HETHERINGTON

SWITCHES • INDICATOR LIGHTS • SPECIAL ASSEMBLIES

ENGINEERING NEWS



SOLVE SPACE AND WIRING PROBLEMS with Switch/Light Combinations

You probably use these Hetherington Switch/Light combinations every time you travel via leading air lines. Here they are used as hostess call lights. As you may have suspected, however, this is just the beginning of their usefulness—both in aircraft as well as in commercial instrumentation and control uses. Their unique combination of single- or double-pole switching action together with an illuminating push button offers definite advantages in terms of greatly reduced panel space and the elimination of switch-to-light wiring. Usually the entire assembly takes no more space than a conventional switch alone.

Of particular importance for many applications, Hetherington Switch/Light combinations make it easier for operators to keep closer tabs on crowded panels without confusing control functions. By connecting the light to an externally controlled circuit the illuminated button virtually cries, *"Push Me,"* to attract the operator's attention at the right time. In other models, lamp circuits are controlled by the main switch contacts or by a second set of auxiliary contacts.

Typical contact ratings are 15 amps at 30 volts ac-dc. Illuminated buttons can be made in virtually any color, shape or size.

Circle 424 on Page 19

HERE'S EXTRA SAFETY FOR WARNING LIGHT APPLICATIONS

JUST "PRESS TO TEST"

Ever wonder whether a warning light for a critical circuit was merely OFF or whether the bulb was burned-out?

If so, you'll appreciate the "Press-to-Test" feature of this tiny Hetherington Type L3200 light.

The lamp and its circuit can be "checked-out" simply by pressing on the spring-mounted plastic lens cap. This makes contact through a separate third terminal circuit. When cap is released, the lamp functions through the regular circuit.

The long plastic lens of the L3200 gives wide, 180-degree visibility with either standard or edge-lit panels. Uses AN3140 lamps. For more details, write for Bulletin L-2b.

Circle 425 on Page 19

BETTER SWITCHES FOR BETTER APPLIANCES

A good electrical product deserves a good switch—and for types in the 5 to 50 ampere range that means Hetherington. Sturdy, good-looking switches —both push button, toggle, rotary, and other types—for unique operating or mounting requirements have long been a Hetherington specialty. Chances are, Hetherington switch engineers can recommend something out-of-the-ordinary that will enhance the appearance and saleability of your electrical products while assuring long, happy switch performance.

NEW PUSH BUTTON SWITCHES FOR AVIATION'S TOUGHEST JOBS . . . *Designed to MIL-S-6743 Specs*

Designed to MIL-S-6743 drawing MS25089, these rugged, fully moisture-proofed snap action switches take a full 50 G shock and wide-amplitude vibrations up to 55 cps without contact transfer.

The basic switch can be fitted with any of eight different anodized aluminum mounting adapters, such as those illustrated, to meet virtually any mounting or design requirement.

Two-circuit, three-terminal, SPDT, and other contact arrangements are available with ratings up to 10 amps, 28 volts dc. Ask for details on Hetherington Series W100.

Similar switches for non-MIL and industrial applications are available in over 1800 different types as Hetherington Series "JR."

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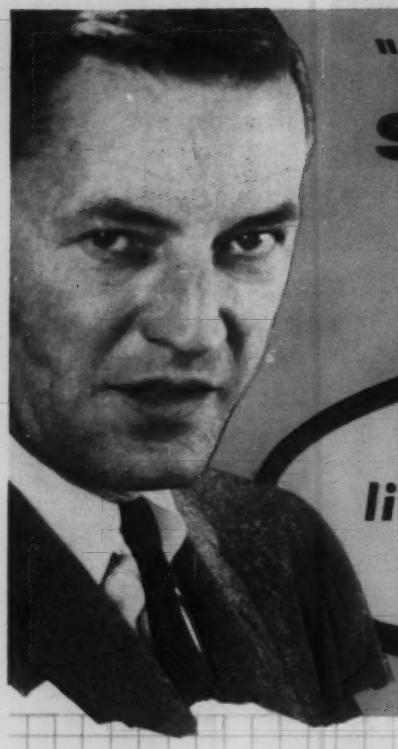
HETHERINGTON INC. DELMAR DRIVE, FOLCROFT, PA. • 139 Illinois St., El Segundo, Calif.

designed for use where one failure is one too many

A Controls Company of America Subsidiary



"Why it pays to STANDARDIZE on *Norgren*"

The world's most complete line of:

- ★ AIR LINE FILTERS
- ★ PRESSURE REGULATORS
- ★ OIL FOG LUBRICATORS

- **ONE SOURCE FOR EVERY FILTER, REGULATOR, LUBRICATOR NEED**

  Whatever your requirements may be for air line filters, pressure regulators or lubricators for bearings or air operated devices... Norgren can supply your needs. In Norgren, you have a wide choice of high quality, top performance equipment to meet your specific requirements... the advantages of one source... all of which adds up to substantial savings in time and money.

- **INTERNATIONAL AVAILABILITY AND SERVICE**

  Norgren representatives and stocking distributors are located in 40 of the principal industrial areas in the United States and in 25 foreign countries. When you have a design or maintenance problem, a telephone call to your nearby Norgren representative will bring quick, expert engineering service.

- **SIMPLIFIED PARTS INVENTORY**

  Extensive interchangeability of parts results in simplified parts inventory.

- **EASIER MAINTENANCE**

  Minimize maintenance costs by standardizing on Norgren... the most complete line. Realize the advantages of standardized design and construction features.

C.A. NORGREN CO.

3442 SOUTH ELATI STREET • ENGLEWOOD, COLORADO

AIR LINE FILTERS—98 Models

Pipe sizes: ¼", ⅜", ½", ¾", 1", 1¼", 1½"

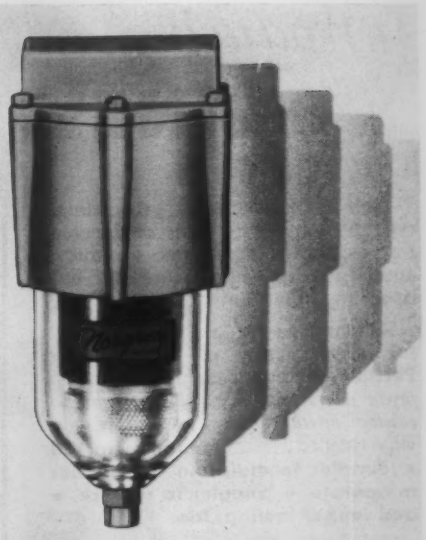
Automatic or manual drain

Transparent or metal bowls

Choice of four filter elements — 74, 64, or 25 micron... 5 micron available in some sizes.

Maximum line pressure: 250 psi

Maximum temperature: 300° F



PRESSURE REGULATORS
Over 400 Standard Models

For air, water, oil, steam and non-corrosive gases.

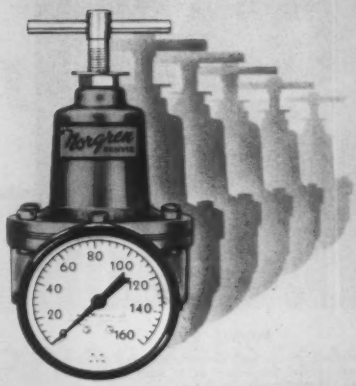
Pipe Sizes: ¼", ⅜", ½", ¾", 1", 2"

Types: Relieving, non-relieving, pilot operated — integral or remote controlled

Maximum line pressure: Air, water, gases — 400 psi
Cylinder gases — 3000 psi

Operating temperature: Steam — up to 450° F
All others — minus 40° to plus 200° F

Available with or without gauges



LUBRICATORS—100 Models

MICRO-FOG for lubricating bearings, gears, chains, slides.

Maximum Bearing-inch ratings: 32, 100, 200, 300, 1000 — makes equipment available for the most economical installation.

MICRO-FOG and Oil-Fog for air-operated devices such as air cylinders and air tools.

Pipe Sizes: ¼", ⅜", ½", ¾", 1", 1¼", 1½"

Oil reservoir capacities: 3 oz., 10 oz., ⅓ pt., ½ pt., 1 qt., 2 qt., 1¾ gal., 2 gal., 4½ gal., 5 gal.

Replaceable transparent or metal bowl
Filters, Regulators and Lubricators can be assembled in any combination that best suits your purpose.

For complete information about any Norgren product ...call your nearby Norgren Representative... or WRITE TO THE FACTORY FOR DESCRIPTIVE LITERATURE

If it's Norgren... It's Dependable.

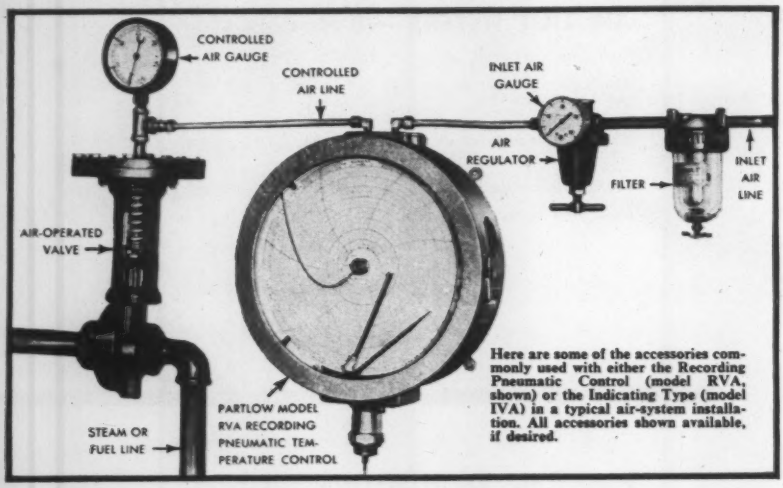
Circle 427 on Page 19

Introducing . . .

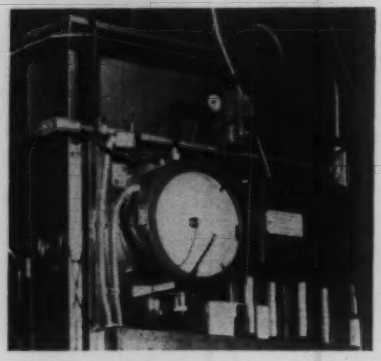
the NEW Partlow Pneumatic Control

New from Partlow . . . throttling-type pneumatic controls engineered to function with extreme accuracy, and sensitivity, under virtually *any* operating conditions.

Actuated as they are by the powerful, direct action of mercury, the Partlow pneumatics actually contain *fewer parts than any other pneumatic control on the market* . . . one reason why they're . . . . **Simpler to install • Simpler to maintain • Simpler to operate • Simpler to replace • and longer lasting, too.**



Here are some of the accessories commonly used with either the Recording Pneumatic Control (model RVA, shown) or the Indicating Type (model IVA) in a typical air-system installation. All accessories shown available, if desired.



MODEL RVA

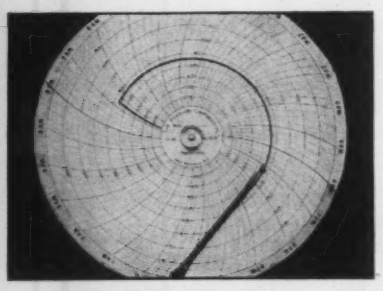
Pneumatic Recording control, installed on new steam-heated cross-flow dryer built by Lydon Bros., Hackensack, N. J.

OUTSTANDING FOR ACCURACY, SENSITIVITY AND FLEXIBILITY

The new Partlow pneumatic controls are accurate to within 1% of scale in any one of 10 ranges from –30° to 1100°F. *Exceptionally sensitive too* . . . providing positive, hair-trigger response even to fractional changes in temperature. *And flexible* . . . with throttling range adjustable anywhere from 3 to 20% of scale range.

COST LESS TO OWN AND OPERATE . . CUT "DOWN TIME" TO A MINIMUM!

Because they contain fewer parts, Partlow pneumatic controls cost less to buy: next to nothing to operate and maintain. *All elements of the same range are interchangeable*, which means they can be replaced right on the job instead of back in the factory . . . 'Down time' is reduced to a matter of minutes. And no expensive inventory of spare parts or spare instruments is ever required.



INSTANT RESPONSE

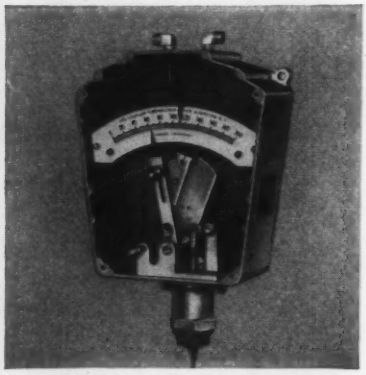
to temperature changes is a key feature of the Partlow pneumatic. Built-in bulb sensitivity teamed with advanced mechanism design means a minimum of saw-toothing on start-up and a fine line of control when the instrument has reached its throttling equilibrium.

IDEAL FOR HAZARDOUS OR 'SHOCK' LOCATIONS!

There are no delicate electronic tubes or gadgets in the Partlow pneumatic to get out of kilter, or possibly trigger an explosion. Its ruggedly simple internal mechanism is virtually shock-and vibration-proof . . provides maximum resistance to moisture, fumes, acid and all types of corrosion. Long-life and trouble-free performance are hallmarks of the pneumatics, as they are of all Partlow controls.

EXCEPTIONALLY VERSATILE TOO!

Both pneumatics — the Recording and the Indicating models — can be used in systems regulating the flow of steam, water or gas . . . or controlling other air-operated devices. Whatever the nature of the heating appliance it actuates, the chances are there's a Partlow pneumatic control to fit your requirements dependably . . . economically . . . *precisely*.



MODEL IVA (interior view)

New Partlow Pneumatic Indicating Control, with throttling range adjustable from 3 to 20%.

SEND US YOUR SPECIFICATIONS

Ask today for a control recommendation tailored for your specific OEM requirements. Of course, if desired, you may field-test this superb new control without cost or obligation. For details write, wire or phone Dept. D-1158.

The Partlow Corp., New Hartford, N. Y.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

Circle 429 on Page 19

Circle 430 on Page 19→

NOW IN
G-E FORM G
MOTORS

27

EXTRA VALUE FEATURES

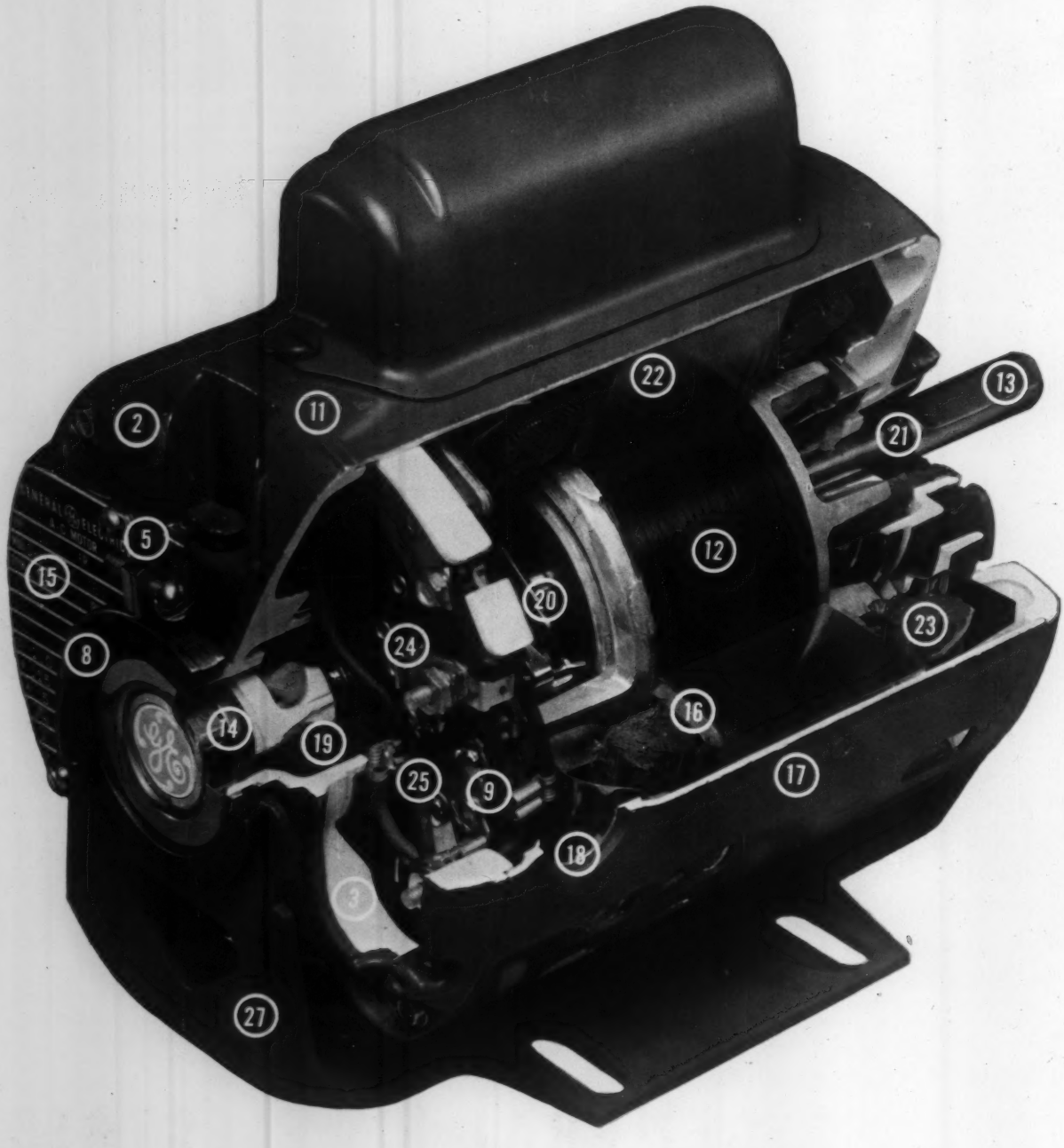
...to help you improve design and quality, cut maintenance and assembly costs

OPERATION upturn
GENERAL ELECTRIC

GENERAL ELECTRIC

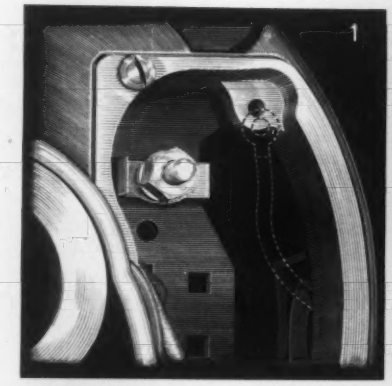
FORM G MOTORS

* Including many brand-new features indicated with red. Together with the many performance-proved Form G features, they add important EXTRA VALUE to General Electric "years ahead" motors. Investigate each of these features carefully. Ask yourself, "How much can I benefit by taking advantage of this Form G feature?"



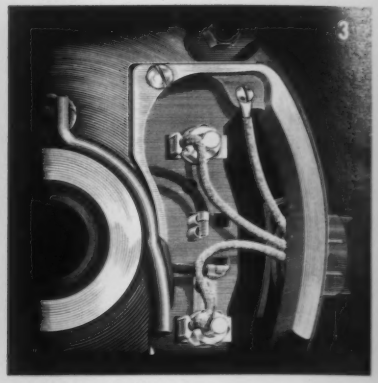
Nos. 1, 4, 6, 7, 10 and 26 not shown on cutaway.

-27 REASONS* FOR



NEW! PERMANENT GROUNDING—with built-in lug you can quickly make ground connections—meets UL standards.

BETTER ALIGNMENT—rugged, disk-type end shield places rabbet and bearing in same plane, means accurate bearing alignment.

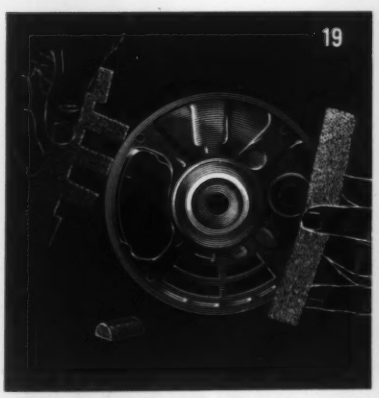


NEW! EASIER WIRING—enlarged wiring compartment affords easier connections, saves assembly time and costs.

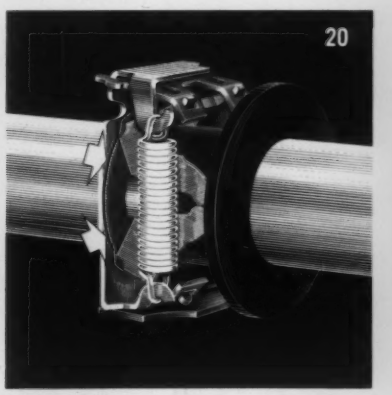
LIGHTER, SMALLER—50% lighter, 40% smaller than old-style models, the new Form G costs less to handle, install, ship.

MACHINED END SHIELD O.D.—close tolerances make possible direct mounting to your product without costly machining.

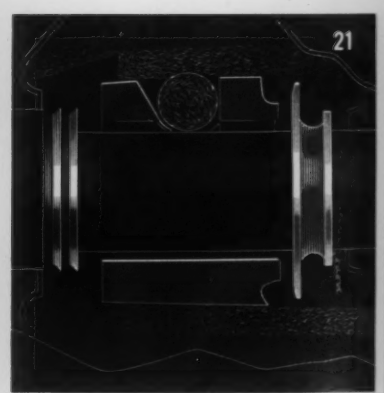
LONG LIFE—dynamically balanced rotors of cast aluminum are virtually indestructible; contribute to quiet operation.



LONG BEARING LIFE—three-wick lubrication system bathes shaft with clear, filtered oil, providing long motor life.

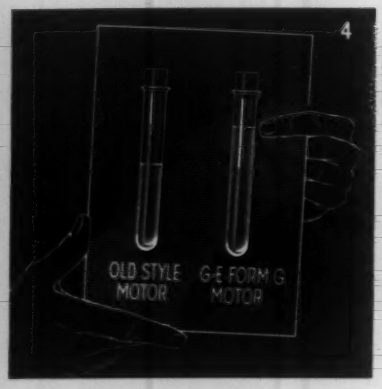


NEW! QUIETER SWITCH—specially designed washer cushions start-stop click, maintains positive snap action.



POSITIVE OIL RETENTION—rubber and metal oil throwers return oil from shaft to wicks, giving exceptional oil retention.

YOU TO BUY NOW



LONG LUBRICATION LIFE—over 50% more oil than in old-design motors contributes to motor's doubled lubrication life.

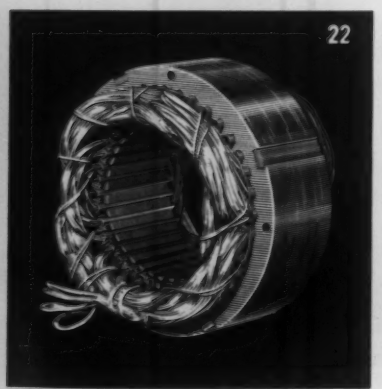
NEW! BETTER APPEARANCE—bright-plated motor hardware looks better longer, resists rust and corrosion.

ALL-ANGLE OPERATION—specially designe bearing and oil retention system allov you to mount Form G's in any positio

NEW! SHAFT PROTECTION—special gun-metal-like treatment of shaft resists rust, simplifies product service.

THRUST ABSORPTION—unique thrust washer assembly withstands normal thrust from any direction regardless of motor angle.

NEW! PERMANENT DATA—en graved, paint-filled nameplate is mor legible; simplifies selection, installation



NEW! LONGER LIFE—heavy-duty bonding dip and stator clamps help provide a more rigid, unitized assembly.

LONG INSULATION LIFE—Formex** wire in Form G motors can be bent, twisted, crushed, yet retains its insulating ability.

NEW! FASTER CONNECTION—plug-in connectors on external and internal terminals cut installation time 50%

V FOR EXTRA VALUE!

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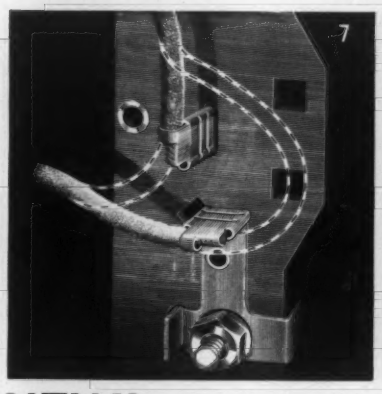
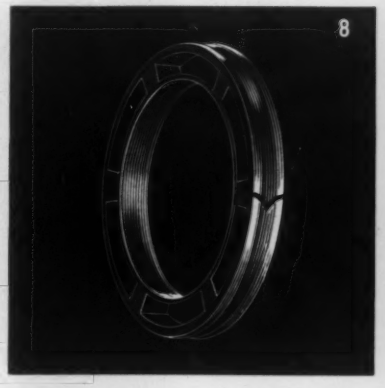
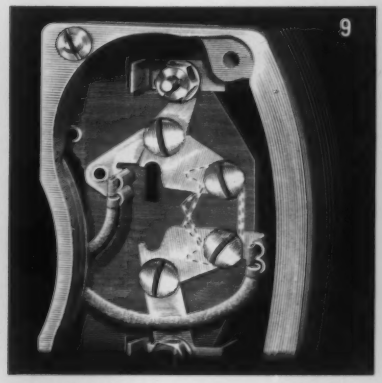
allows
osition.



NEW! FAST ROTATION CHANGE—quick connects make changeover fast and positive. Just switch two motor leads.

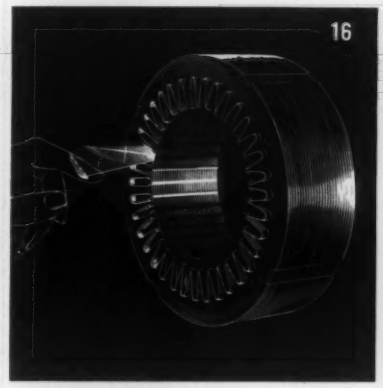


QUIETER OPERATION—improved mounting rings provide greater resiliency, and contribute to quieter motor operation.

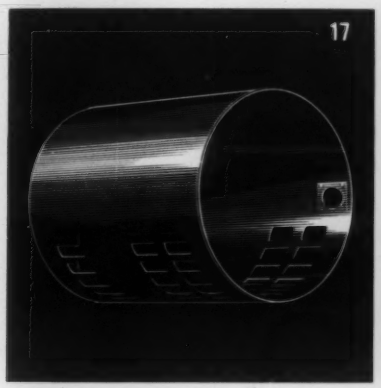


NEW! FAST VOLTAGE CHANGE—ingenious sliding plates let you switch from 115v to 230v or vice versa in seconds.

A—en-
more
llation.



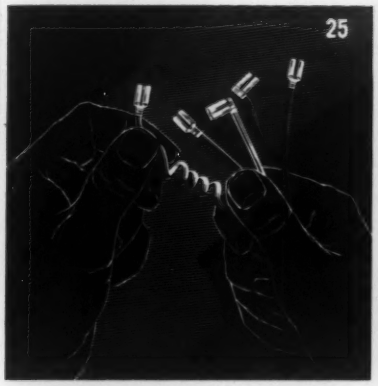
LONG LIFE—Mylar† has 35 times the moisture resistance, 8 times the dielectric strength of ordinary paper insulation.



RUGGED CONSTRUCTION—sturdy steel shell keeps end shields accurately aligned, protects motor from rough treatment.

FAST CONDUIT CONNECTION—speed nut, securely welded inside motor shell, reduces conduit connection time 50 per cent.

ION—
inter-
50%.



LONG LEAD LIFE—braidless neoprene leads resist heat, moisture and aging; and are color-coded for easy identification.

NEW! MORE LEGIBLE INSTRUCTIONS—oiling instructions, lithographed on terminal box cover, *stay* legible.

†Reg. trademark of duPont Co.

MOUNTING VERSATILITY—resilient and solid cradle bases permit rotation of G-E motor within base to meet design needs.

**Reg. trademark of General Electric Co.

PULL TAB

. . . And Here's How These

G-E MOTOR EXTRA VALUES C

DEPENDABILITY PLUS—"Our controlled volume pumps and chemical feeding system are highly accurate devices used for metering corrosive chemicals. We demand absolutely dependable motors. Power failures can be expensive for our customers and detrimental to our reputation. The Form G answers our needs completely. Its many features assure built-in dependability and top-notch performance."

PRACTICALLY MAINTENANCE-FREE—"Using G-E Form G motors on our Keenco Automatic Poultry Feeders has proved to be a practical and profitable way to meet customer demands for continuous, dependable service with virtually no maintenance. We're convinced that the many features in General Electric motors add real extra value to our products—and help us gain extra customer satisfaction."

SAVE $9 PER UNIT—"When we started using motors exclusively on our egg washers we re these benefits: (1) we now save 27 man-hou every 25 units produced; (2) we save about $ machine because the close tolerances of the G end mounted motor eliminate special mou brackets; (3) our product is now much smalle lighter; and (4) we've been able to reduc 'Cascade' unit price by $15."

VERSATILE MOUNTING—"We've realized big sa by using Form G motors on our Edwards auto door operators. For instance, the cradle base lets the motor rotate to any position can be ins in our equipment before we mount the mo means faster assembly. The Form G's small has also allowed us to design a lighter, more pact and attractive unit. We've had no comp since switching to G-E motors four years ag

CAN PAY OFF FOR YOU

using G-E
we realized
n-hours per
bout $9 per
the Form
l mounting
smaller and
reduce our

big savings
automatic
base which
be installed
e motor—
small size
more com-
complaints
rs ago."

ALL-ANGLE MOUNTING—"We've standardized on G-E Form G motors for our Star Milk Coolers for two big reasons: (1) it requires no special end shield or bearings for shaft-down mounting and we can use simple through bolts to mount it; (2) it requires minimum maintenance even under severe climatic conditions."

INCREASED SALEABILITY—"Form G motors have resulted in a big weight saving, giving our ventilators a sizeable competitive edge. Also, we especially like G.E.'s Small Motor Service Station Plan which assures customers fast, local service if needed. Because of this excellent service we use General Electric motors exclusively."

66% SMALLER SIZE—"Compactness and high power per pound makes General Electric motors ideal for our proportioning pumps. Using Form G motors permits a 66% size reduction, a 50% pumping capacity increase and a 50% price reduction."

* PROPORTIONEERS DIVISION

NOW WITH NEW EXTRA VALUE

You can now get these 27 General Electric Extra Value Features on the complete Form G line.

Like these manufacturers, you, too, can get real extra value by specifying Form G motors. Over 850 basic models—and thousands of variations—will soon be available in quantity, equipped with the new extra value features. And in most cases, there's a standard Form G motor to meet your exact product requirements, eliminating the need for costly "specials."

BUY NOW
FOR EXTRA
VALUES

OPERATION upturn
GENERAL ELECTRIC

GENERAL ELECTRIC

HAVE YOU PERSONALLY REVIEWED THE G-E FORM G MOTOR STORY RECENTLY?

DO YOU KNOW that *only* General Electric offers you a *complete* line of fhp motors in the new, compact design? And *only* from General Electric can you get *all* these 27 important features, including the NEW EXTRA VALUE FEATURES. It *pays* to standardize on G.E.'s full line of "years ahead" motors. Why not investigate them today?

Start by calling your General Electric Sales Engineer. Ask him to review with you the Form G story just as soon as possible. He has a complete schedule of the availability of the new extra value features and he'll be glad to show you exactly how you, too, can gain all the important advantages of General Electric Form G motors.

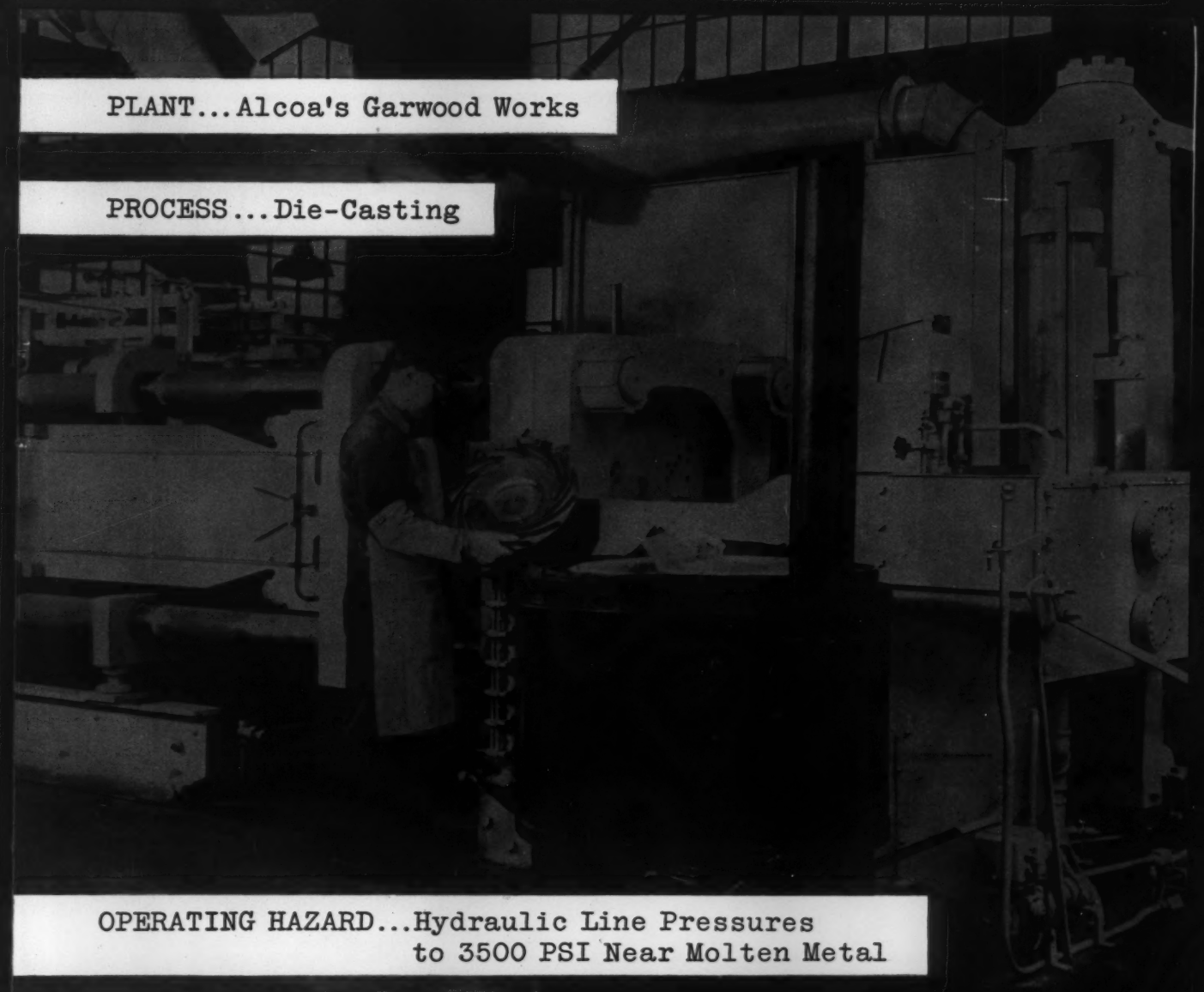
702-88

BUY NOW FOR EXTRA VALUES

OPERATION upturn
GENERAL ELECTRIC

Progress Is Our Most Important Product

GENERAL ELECTRIC



PLANT...Alcoa's Garwood Works

PROCESS...Die-Casting

OPERATING HAZARD...Hydraulic Line Pressures to 3500 PSI Near Molten Metal

DANGER...Line Break

Hydraulic Fluid Used...FIRE-RESISTANT CELLULUBES

A 750-ton cold chamber die-casting machine at Alcoa's Garwood plant. Holding furnace in foreground contains molten metal, is close to pressurized hydraulic fluid lines.

In die-casting operations at its Garwood Works, Aluminum Company of America uses fire-resistant Cellulube hydraulic fluids to minimize the danger of fire in case of a break in hydraulic lines serving the die-casting machines.

Although there have occasionally been line breaks, under pressures ranging up to 2,000–3,500 psi, no serious fires have ever resulted. In addition, Alcoa has found that Cellulube fluids not only perform well as hydraulic media, but lubricate pump parts well.

Cellulubes . . . the *safe* hydraulic fluids . . . are available in six controlled viscosities (90, 150, 220, 300, 550, and 1,000 S.U.S. at 100°F), one of which is best suited to your operations and the safety of your plant and personnel. If you'd like a sample for evaluation, please let us know the application involved.

Celanese Corporation of America, Chemical Division, Dept. 545-K, 180 Madison Avenue, New York 16, New York. Celanese® Cellulube®

Cellulubes... Celanese CHEMICALS fire-resistant functional fluids

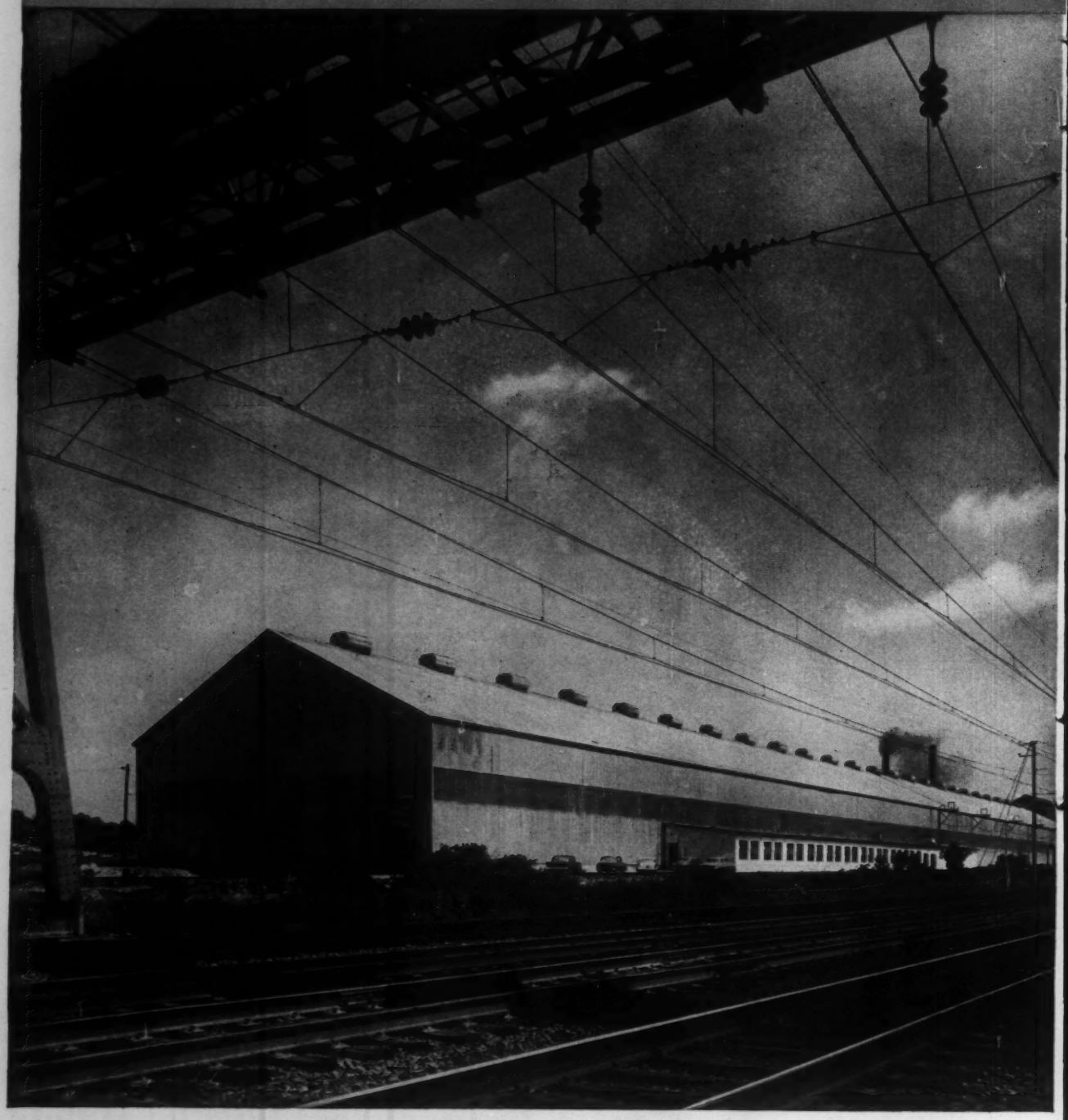
Canadian Affiliate: Canadian Chemical Co., Limited, Montreal, Toronto and Vancouver • *Export Sales:* Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Avenue, New York 16, N. Y.

←Circle 430 on Page 19

Circle 431 on Page 19

need steel parts?

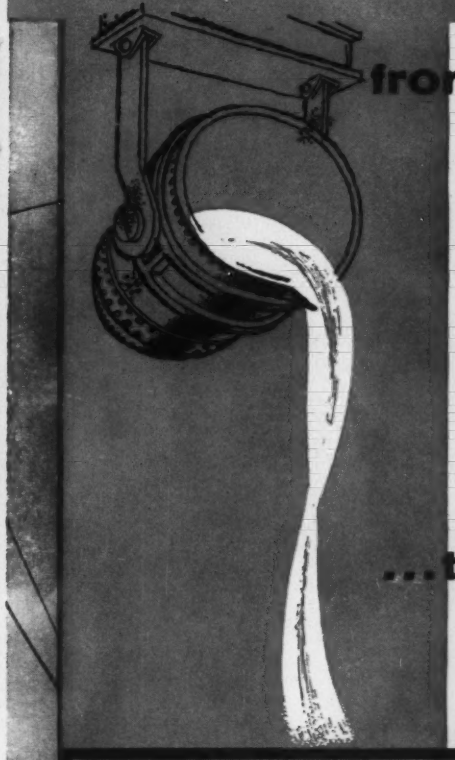
integrated operations



Claymont's new 100,000 square foot fabrications shop.

... try CLAYMONT

provide you with these advantages



...from STEEL PRODUCTION

Claymont is integrated—produces all its own steel. Your source of supply is assured.

QUALITY CONTROLS

Claymont controls, tests, inspects throughout every stage of production—within our own plants.

MODERN EQUIPMENT

Claymont's complete range of fabricating equipment performs all these steel plate operations:

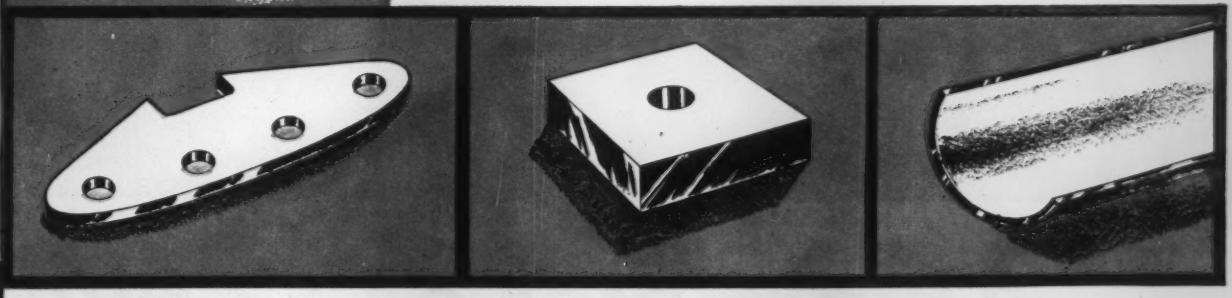
Welding • Shearing • Punching • Milling • Machining • Painting
Bending • Cutting • Boring • Grinding • Chipping • Edge Preparation
Rolling • Pressing • Drilling • Shaping • Priming • Shot Blasting

COMPLETE FACILITIES

100,000 sq. ft. of efficiently organized, production-line Fabrications Shop floor space; streamlined shipping facilities; ready accessibility to water, rail, highway transportation.

...to FABRICATED STEEL PARTS

Claymont provides production weldments or job-shop fabrications in a wide variety of sizes and types of steels; is geared to handle small- or large-quantity jobs with equal facility.



Claymont can meet your steel parts requirements. Contact our nearest office today.

CF&I

Claymont Steel Products

Products of Wickwire Spencer Steel Division • The Colorado Fuel and Iron Corporation

Albuquerque • Amarillo • Atlanta • Billings • Boise • Boston • Buffalo • Butte • Casper • Chicago • Denver • Detroit • El Paso • Ft. Worth • Houston • Lincoln • Los Angeles New Orleans • New York • Oakland • Odessa • Oklahoma City • Philadelphia • Phoenix • Portland (Ore.) • Pueblo • Salt Lake City • San Francisco • San Leandro • Seattle • Spokane Tulsa • Wichita—**CF&I OFFICES IN CANADA:** Montreal • Toronto—**CANADIAN REPRESENTATIVES AT:** Calgary • Edmonton • Vancouver • Winnipeg

OTHER CLAYMONT PRODUCTS

Alloy Steel Plates • Large Diameter Welded Steel Pipe • Manhole Fittings and Covers • Flanged and Dished Heads
High Strength Low Alloy Steel Plates • Stainless-Clad Plates • CF&I Lectro-Clad Nickel Plated Steel Plates

5497

Circle 432 on Page 19

This motor can drive

This squirrel cage, open frame, integral horsepower Century Electric motor works fine on dozens of applications. You'll find it giving dependable low-cost service on blowers, fans, pumps, lathes, drilling machines and grinders. **But . . .**

It can't do everything. There are many applications where it won't give good results. That's why you can't use just any motor on your equipment. You need the right motor. The motor that gives you the right combination of torque, horsepower, acceleration and efficiency for you to get top performance from your equipment.

Century Electric can help you get that right motor. Here's why: Century Electric sales engineers are motor experts. They know motors and drive problems inside and out because they think, sell and apply motors and nothing but motors. They can give you on-the-spot answers.

anything . . . almost

Over 10,000 types of motors are available from Century Electric. There is one for every type of application and any operating condition—dusty, corrosive, explosive or moist. Century Electric sales engineers will help you select the right one. They don't have to rely on few types, like this standard squirrel cage motor, to do everything.

For more than a motor—for help in selecting the right motor for your application, just contact your nearest Century Electric Sales Office or Authorized Distributor. A Century Electric sales engineer will be glad to help you.

CENTURY ELECTRIC COMPANY

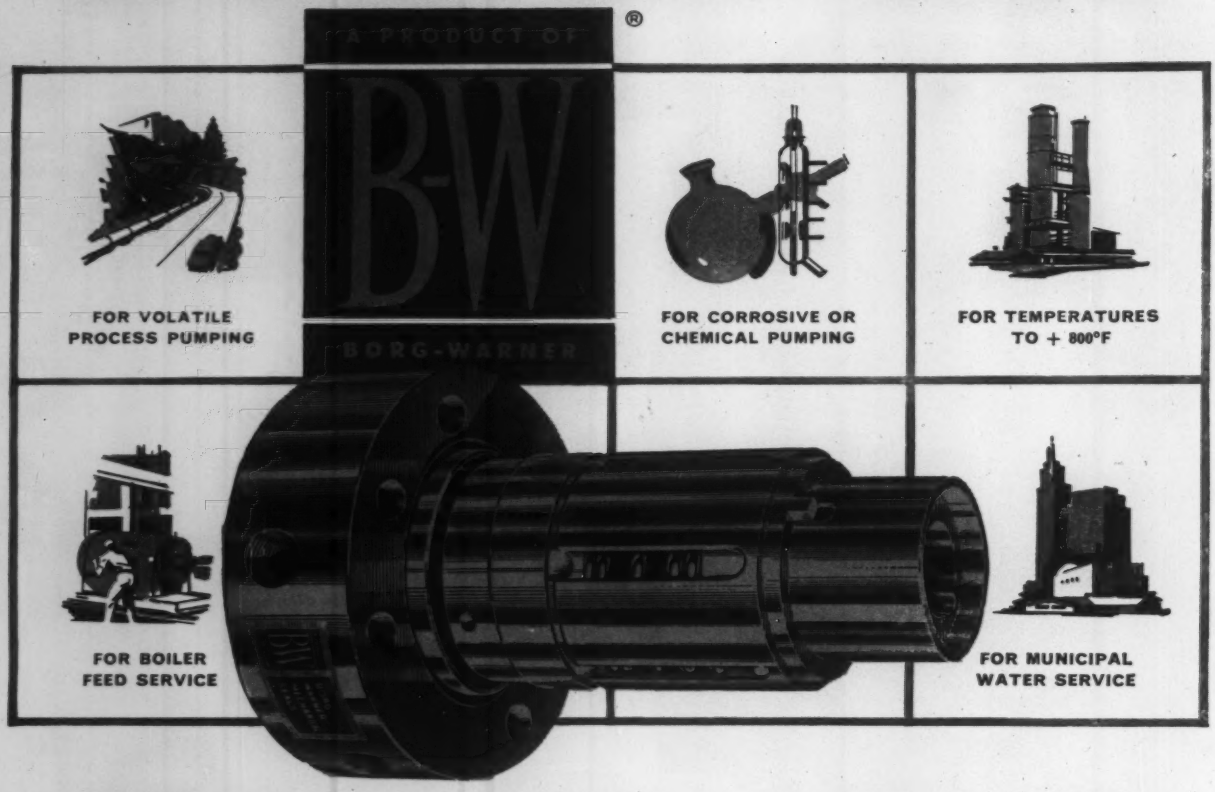
St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Circle 433 on Page 19

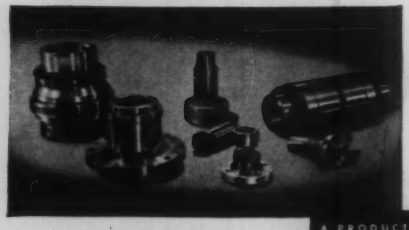
Century

58-1

Now...Borg-Warner® Mechanical Seals



Precision shaft seals for all makes and models of centrifugal pumps...and other rotating shaft sealing applications



A PRODUCT OF B-W BORG-WARNER

Because of their wide acceptance and rapid growth, the complete line of mechanical seals—developed and perfected by Byron Jackson—now becomes a separate, industrial division of Borg-Warner.

Borg-Warner Mechanical Seals are now available for almost every make, model and size centrifugal pump... almost every pumping condition... and for other difficult rotating shaft sealing applications.

Even under critical conditions of pressure, volatility, toxicity, corrosion, abrasion and other tough fluid handling jobs, these precision mechanical seals furnish completely reliable stuffingbox performance. They're easy to install and maintain... eliminate expensive downtime and repacking.

This new Borg-Warner Mechanical Seal Division provides larger, more efficient sales, engineering, manufacturing and service facilities. It concentrates an even greater research and development program to create new and improved seals for tomorrow's shaft sealing needs.

Send for the new Borg-Warner Mechanical Seal bulletin—there's no obligation!

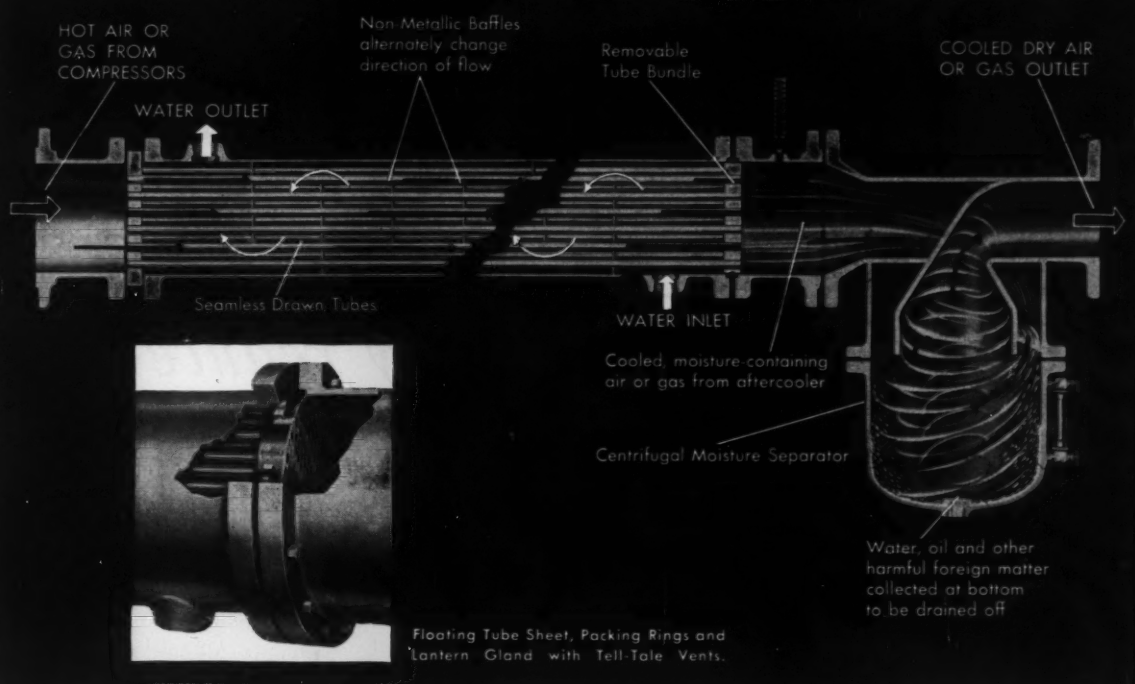
Borg-Warner Mechanical Seals

Division of Borg-Warner Corporation

P.O. Box 2017A, Terminal Annex, Los Angeles 54, California

Circle 434 on Page 19

the more you see... the more apparent it becomes


HOT AIR OR GAS FROM COMPRESSORS
WATER OUTLET
Non-Metallic Baffles alternately change direction of flow
Removable Tube Bundle
COOLED DRY AIR OR GAS OUTLET
Seamless Drawn Tubes
WATER INLET
Cooled, moisture-containing air or gas from aftercooler
Centrifugal Moisture Separator
Water, oil and other harmful foreign matter collected at bottom to be drained off
Floating Tube Sheet, Packing Rings and Lantern Gland with Tell-Tale Vents.

NEW ROSS PIPELINE AFTERCOOLERS

are today's most effective means of cooling and drying compressed air

Here, cut away for your inspection, is the new Ross Type A-100 Pipeline Aftercooler . . . the "inside story" with everything revealed.

Note how the air in the tubes flows counter to the water in the shell so that the coldest (incoming) water serves the coldest (outgoing) air. Note, too, how the air is baffled into a swirling eddy within the moisture separator to force (centrifugally) water and all other entrainment from the line.

Examine every feature! The more you see, the more apparent it becomes: *This new aftercooler is the most efficient unit ever built for air compressor service.*

Equally important is the fact that fully standardized parts are utilized to eliminate costly "specials" in both engineering and fabrication. You save in every way.

Compact and easy to install, a Ross A-100 can be readily fitted into any compressed air system. There are 51 models to choose from, with capacities ranging from 0 to 36,000 scfm at operating pressures up to 150 psig for single or two stage compression.

Why not see all there is to see? New Bulletin 302.6K1 contains the complete, illustrated story as well as specifications. Send the coupon for your copy now.

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AMERICAN-Standard
ROSS HEAT EXCHANGER DIVISION

Mail this coupon for new Bulletin

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American-Standard
Ross Heat Exchanger Division
Buffalo 5, N. Y.

SEND your new Bulletin 302.6K1 describing Ross Type A-100 Pipeline Aftercoolers.

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MD 1186

Castings of

ARMASTEEL®

so tough they replace forgings so machinable...they reduce finishing costs

CLASSIFICATION	CHARACTERISTICS	HARDNESS (BHN)	MIN. TENSILE STRENGTH (PSI)	MIN. YIELD STRENGTH (PSI)	MIN. % ELONGATION IN 2 INCHES
ARMASTEEL GM 86M	Recommended for less highly stressed parts. Replaces steel parts in 1020-1035 S.A.E. range.	163-207	70,000	48,000	4.0
ARMASTEEL GM 85M	Recommended for moderate strength plus adaptability to selective hardening. Replaces parts in 1035-1050 S.A.E. range.	197-241	80,000	60,000	3.0
ARMASTEEL GM 84M	Recommended for high degree of strength. Replaces heat-treated parts in 1040-1050 S.A.E. range.	241-269	100,000	80,000	2.0
ARMASTEEL GM 88M	High resistance to wear and high yield strength, yet retains machinability. Requires no heat-treating and possesses same strength and wear characteristics as alloy steel forgings.	269-302	105,000	85,000	2.0

CENTRAL FOUNDRY DIVISION

Because ARMASTEEL castings are so machinable, so resistant to wear and shock, and so adaptable to selective hardening, they are rapidly replacing many parts formerly machined from bar stock or steel forgings.

ARMASTEEL, a pearlitic malleable iron, possesses the same strength and performance characteristics usually associated with plain carbon steel. In addition, ARMASTEEL contains excellent bearing properties, has high yield strength, good damping capacity, maximum rigidity and excellent fatigue life. Accurate control of heat-treating operations in the manufacture of ARMASTEEL produces a fine, uniform grain structure and provides excellent finishing qualities.

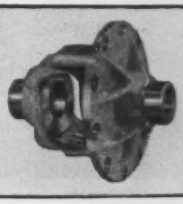
Four different types of ARMASTEEL can be cast to your specifications. One of the four (GM 84M, GM 85M, GM 86M or GM 88M) will have the physical properties to best meet the requirements of your application. For example, ARMASTEEL castings are being successfully used in the automotive, appliance and implement fields for such parts as gears, pistons, crankshafts, rocker arms and universal joint yokes, all of which utilize to best advantage the outstanding characteristics of ARMASTEEL.

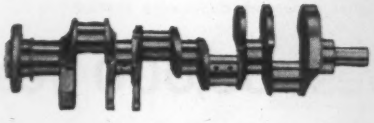
Some of these applications are shown in the table. Look them over carefully; you may find that these characteristics and advantages of ARMASTEEL can help reduce your costs . . . increase your production . . . and improve the performance of your products.

Typical ARMASTEEL castings

Because of the greater physical properties of GM 86M ARMASTEEL, it was possible to redesign this anchor plate as shown and effect a weight reduction from 2.26# per piece to 1.44# per piece.

GM 86M ARMASTEEL provides the ideal casting for this automobile differential case because of its high strength, minimum deflection and good damping qualities which contribute to quietness of operation. Note the as-cast internal cavity and the well-formed webs.



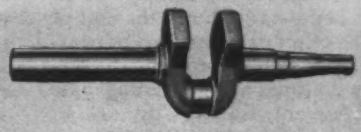


GM 85M ARMASTEEL provides a crankshaft with more desirable machining characteristics than a forged crankshaft of SAE 1045 steel. Improves machining of journals and reduces cheeking stock. Use of GM 85M ARMASTEEL made possible the redesign of the crankshaft with a resulting 3.5# weight reduction and a lower material cost.

By converting to GM 85M ARMASTEEL, drilling and boring operations were eliminated on this crankshaft sprocket. Stock in rough part was reduced from 1.93# in forging to 1.00# in casting. Customer realized reduced piece price with GM 85M ARMASTEEL.

GM 84M ARMASTEEL was specified for this socket plate journal because its microstructure makes it more easily machined than steel with the same physical properties. It has better bearing and wear resistance qualities . . . less distortion during machining . . . and does not require heat treatment. Weight of part in rough is less than comparable steel forging.

Crankshaft for newly designed small gasoline engine. GM 84M ARMASTEEL specified because of outstanding success in similar engines. Less stock removal and better machinability are advantages over forged crankshaft.



This planet gear carrier was formerly forged from SAE 1141 steel, which required a heat treatment after rough machining and broaching operations. By converting to GM 88M ARMASTEEL, heat treatment was eliminated and the weight of the rough part was reduced.

By converting to GM 88M ARMASTEEL for this universal joint yoke, hole thru hub could be cast in . . . eliminating a drilling operation and reducing weight of part approximately 30%. GM 88M ARMASTEEL part has lower piece price than forging formerly used.

85

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 14

thanks to *automatic* xerography...

A. Z. Mellon, left, supervisor, reproduction department, at Westinghouse jet engine plant, Kansas City, and O. D. Lambirth, section engineer, examine a series of offset paper masters that emerge as a continuous roll at the rate of 20 feet a minute from the XeroX® Copyflo® 11 continuous printer, background. The Copyflo printer has cut Westinghouse's average cost of preparing a master from 40 to 8⅔ cents, and saved additional time and money in other paperwork duplicating applications.

Westinghouse of Kansas City Saves $35,000 yearly

A XeroX® Copyflo® 11 continuous printer—*automatic* xerography at its brilliant best—has reduced the cost of preparing offset paper masters by nearly 80%, and stepped up reproduction capacity 25 times at the Westinghouse jet engine plant, Kansas City.

In so doing the Copyflo printer is turning out clear, high-quality, paperwork reproduction at a faster rate than the division ever attained previously by any other method.

The Copyflo continuous printer is saving Westinghouse $35,000 yearly. Recent changes in plant operations that will permit greater utilization of the Copyflo printer are expected to double those savings.

Prior to its installation, the cost of preparing an offset paper master, for instance, was approximately 40 cents. Now it is 8⅔ cents.

Westinghouse previously could turn out only 200 masters a day. Recently, it prepared 617 *in one hour* on the Copyflo printer.

Reproduction work at the Aviation Gas Turbine Division in Kansas City consists largely of forms, sketches, engineering drawings, change notices, and specifications. An important part of the volume is the reproduction of operational lineups, of which 100,000 to 140,000 a month are turned out.

Of priceless worth to Westinghouse is the speed with which engineering-drawing changes now reach production lines. Changes are distributed sooner, thus saving tremendously in machining operations.

A Copyflo continuous printer is an automatic copying machine operating on the electrostatic principles of xerography to produce dry, positive prints or offset paper master ready for immediate use. The prints or masters—in enlarged, reduced, or the same size—emerge from the printer at the rate of 20 feet a minute on a 2,000-foot continuous roll 11 inches wide.

Wherever fast and economic copying of thousands of *different* documents is the need, look to the Copyflo continuous printer for the happy solution. For full details write HALOID XEROX INC., 58-190X Haloid Street, Rochester 3, New York. Branch offices in principal U. S. and Canadian cities.

HALOID XEROX

Circle 437 on Page 19

IT'S NEW

IT'S A PUSH-IN NUT

light

finger

s

for

PATENT PENDING

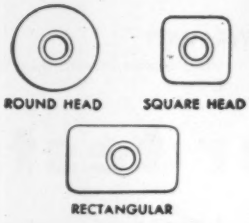


TABLE OF DIMENSIONS

For use with #8 or #10 screws, finished hole size .290/.281, application thickness .030/.060. Other sizes available soon.

HEAD SIZE	HEAD HEIGHT
7/16" DIA.	.150
1/2" DIA.	.030
1/2" DIA.	.040
1/2" DIA.	.070
1/2" DIA.	.150
1/2" DIA.	.100
3/8" SQ.	.040
3/8" SQ.	.140
13/32" SQ.	.030
13/32" SQ.	.200
3/8" x 37/64"	.060

This new Dot Nylon Push-in Nut offers additional design and performance advantages over our currently available plastic snap-in nuts. These advantages are:

(1) Straight legs permit easy insertion in square, punched holes and do not distort the holes even in soft aluminum or thin-gauge steel. (2) Burrs do not impede the nut or prevent proper seating. (3) Tapered screw hole causes legs to spread when screw is inserted and results in greatly increased pull-out resistance (see drawing A).

Ordinary sheet metal screws cut clean, strong threads in the molded nylon and the nut is both re-usable and highly resistant to vibration.

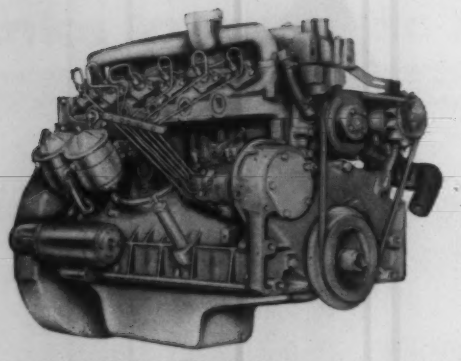
Used as a nut or as a spacer, Dot's Nylon Push-in Nut has wide application in all products where sheet metals or plastics are employed. They can be supplied with a moisture resistant sealer and special nuts can be designed to your specifications if volume warrants. Currently available in eleven sizes. Full information on request.

CARR FASTENER COMPANY

Division of United-Carr Fastener Corp., Cambridge 42, Mass.

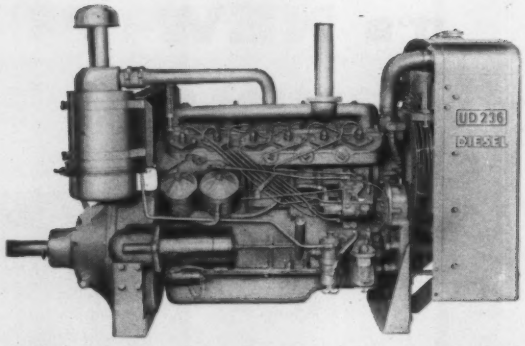
MAKERS OF **DOT** *FASTENERS*

Circle 438 on Page 19



UD-282 6-CYLINDER ENGINE

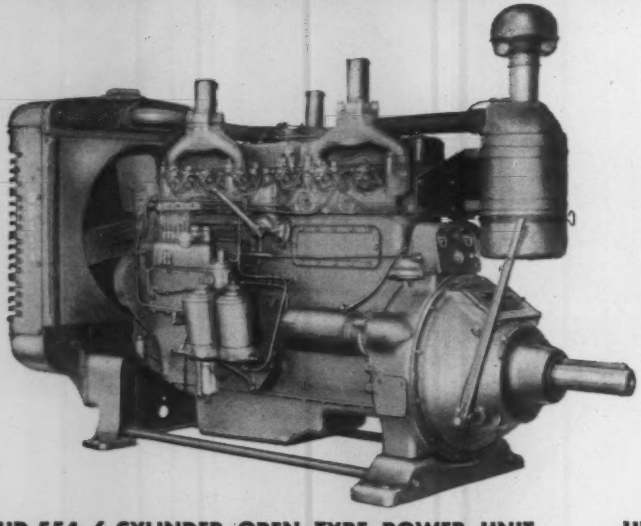
Max. engine hp—95 @ 2400 rpm. Direct electric starting. 3-11/16 x 4.39. 282 cu in displ. 18:1 compression ratio. Matched power unit components available.



UD-236 6-CYLINDER OPEN TYPE POWER UNIT

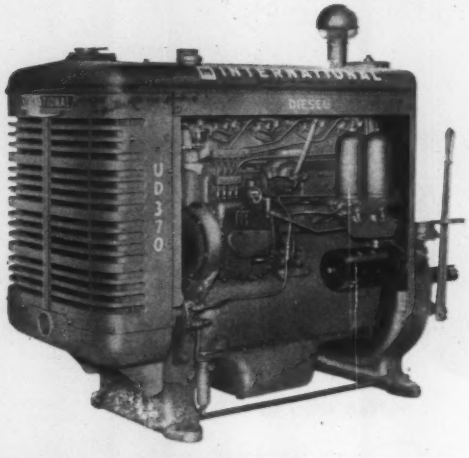
Max. eng. hp—75 @ 2400 rpm. Direct electric starting. 3-11/16 x 3-11/16. 236 cu in displ. 17.5:1 compression ratio.

Four new diesel engines that



UD-554 6-CYLINDER OPEN TYPE POWER UNIT

Max. eng. hp—150 @ 2300 rpm. All weather electric starting. Bore and stroke: 4⅜ x 5½. 554 cu in displ.



UD-370 4-CYLINDER POWER UNIT

Max. eng. hp—95 @ 2200 rpm. Gasoline conversion starting. Bore and stroke: 4⅜ x 5½. 370 cu in displ.

pass all product power tests

Spend five minutes comparing these four new International diesel engines against any checklist you or your customers might use and you'll discover they pass all product power tests!

Well-known manufacturer? The No. 1 builder of 6-cylinder engines built exclusively for heavy duty. Dependable and economical? The very two features that win international acceptance for these engines. Components? All matched power unit components needed to speed installation including air cleaner, base, radiator, and enclosure. Field service? No engine manufacturer supplies finer on-the-job parts and service support in the domestic or foreign markets. Price? Compare and you'll find the price tags on these Internationals as pleasing as their performance.

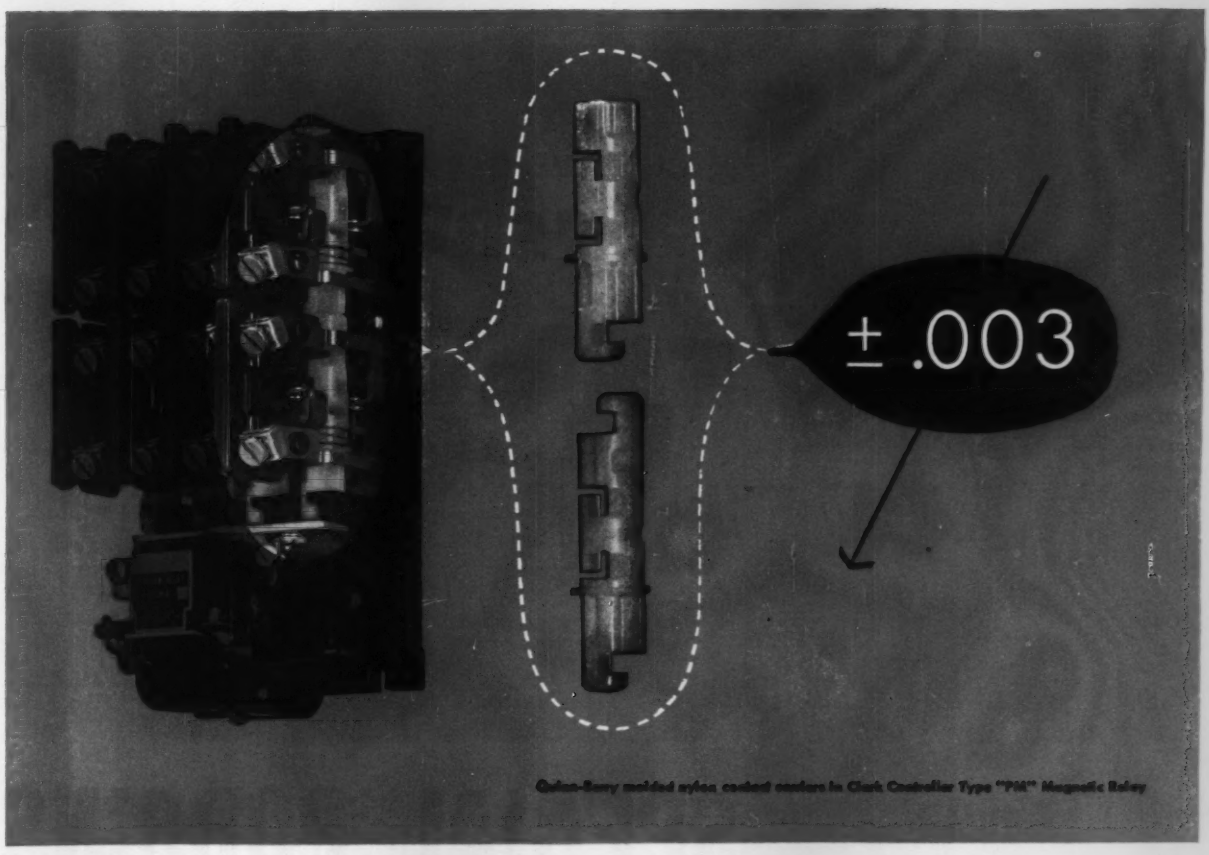
Follow-through? Just write International Harvester Co., Construction Equipment Division, Melrose Park, Illinois. You'll get complete information on these new engines or any of 22 International 4, 6, and V-8 engines.

International® Construction Equipment

International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois

A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.

Circle 439 on Page 19



Impossible Tolerances In Molded Nylon?

.....not at *Quinn-Berry*

Extremely close tolerances, dimensional stability, high wear-resistance . . . these were the demanding specifications for the contact carriers shown above. Quinn-Berry's answer to the problem: careful choice of the right plastics material . . . precision mold design and manufacture . . . skilled pressroom craftsmanship. The result: components of consistent quality which contribute to the trouble-free performance of the Clark Type "PM" Magnetic Relay.

Step by step, under one responsibility and one control, every job is engineered from die design to finished product at Quinn-Berry where the "Unusual Is Routine" in molded thermoplastics. Consult with us in full confidence of the desired result.

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Chelsea 3-3484

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Phone: Ludlow 6-0082

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John Weiland, Jr.
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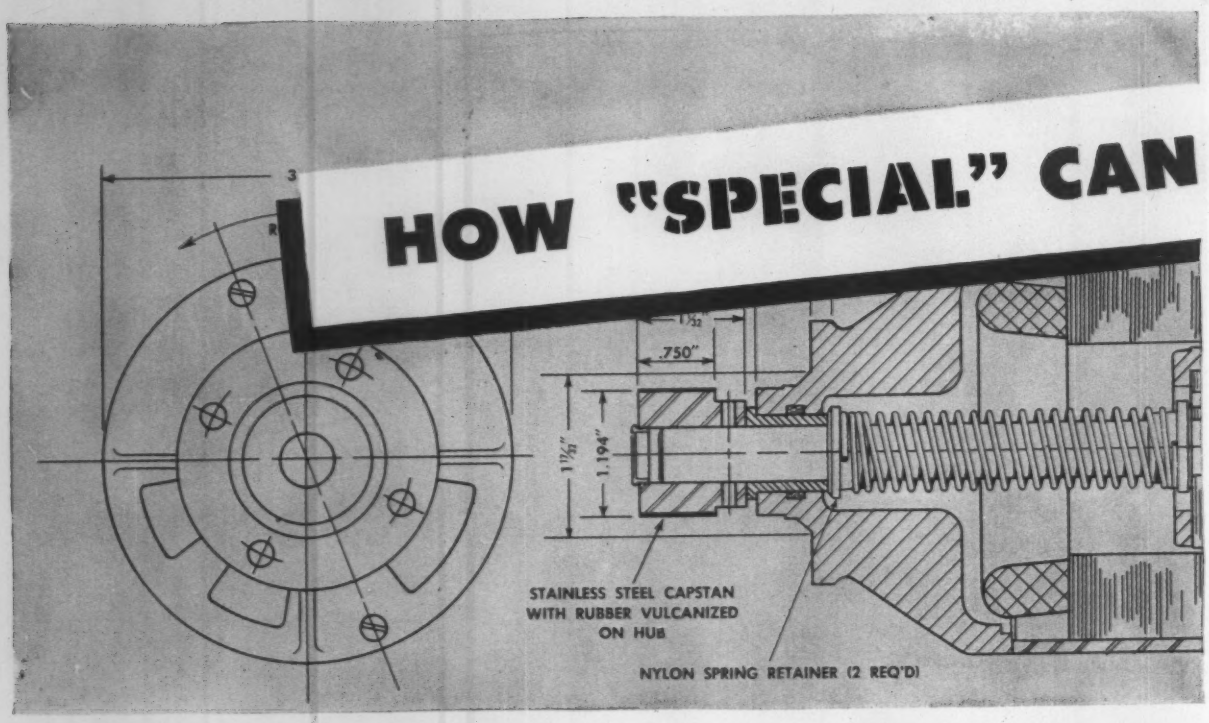
WE FLY TO SERVE YOU FASTER!

QUINN-BERRY CORP.
2609 WEST 12TH STREET, ERIE, PA.
MOLDERS OF ALL TYPES OF THERMOPLASTICS

Circle 440 on Page 19



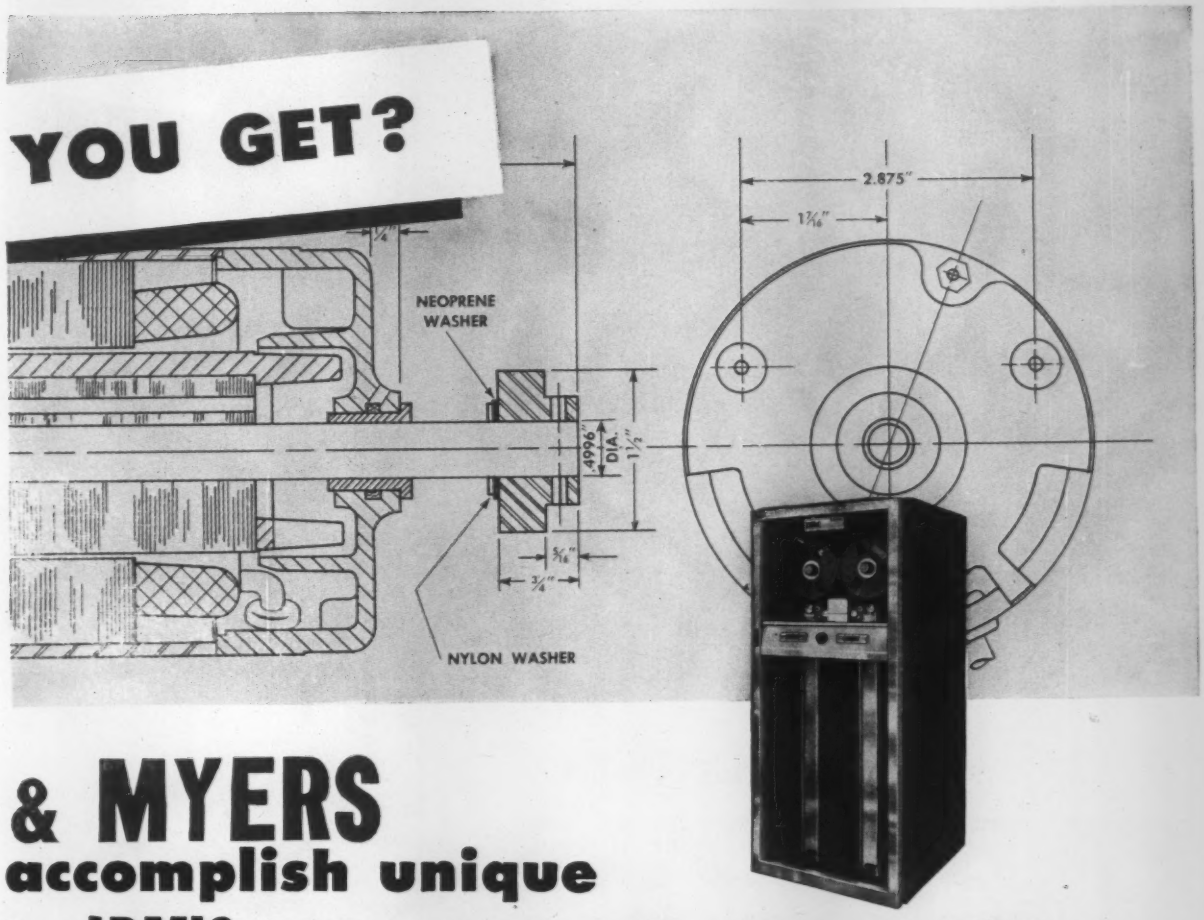
SPECIAL ROBBINS capstan motors function

SPECIFICATIONS

Reluctance synchronous motor, 1/20 HP, 60 cycle, 3 phase, 208 volts ± 8%, 1200 RPM . . . Rotor dynamically balanced to commercial specifications . . . Shaft is shown in position when motor is stopped . . . When motor is running at synchronous speed, a minimum axial force of 350 grams is required with spring in place before displacement occurs . . . When rotor is in its retracted position and power is applied, the minimum axial force developed with spring in place is 100 grams . . . When power is cut off, the spring retracts the rotor with minimum 50 gram force while rotor is rotating.

Robbins & Myers
builds motors from
1/200 to 200 horsepower

YOU GET?



& MYERS
accomplish unique
in IBM'S 727 magnetic tape unit!

SHAFT ROTATES AND MOVES AXIALLY

Two of these special R&M motors are used in each of IBM's 727 Magnetic Tape Units. They answer IBM's need for a tape unit drive motor with a retractable capstan. The rotating shaft moves axially when the motor is started or stopped.

A spring holds the rotor, shaft and capstan in retracted position when the motor is stopped. When started, as the motor attains synchronous speed, axial force created as the rotor centers itself in the field becomes sufficient to overcome spring resistance. The capstan moves into engaged position and sends the tape reels rolling. Another capstan on the opposite end of the shaft (at right in drawing) actuates two microswitches as the rotor returns to retracted position when motor is stopped.

Four additional R&M fractional horsepower motors perform other high-speed power tasks within the tape units—driving reels, rewinding, unloading tape and retracting guide mechanisms.

R&M motors meet strict IBM engineering requirements: precise adaptability to special functions, capacity for lightning starts and stops, and absolute dependability. R&M can also design and build motors of highest quality designed to your exact specifications. For reliable fractional power, contact Robbins & Myers!

R&M

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO

MOTORS · FANS · HOISTS · MOYNO PUMPS · INDUSTRIAL PROPELLAIR FANS

Circle 441 on Page 19

In every one of Detroit's

FABULOUS 59's

dependable National Oil Seals

Year after year, Detroit achieves the impossible—improving constantly on the best cars in the world.

Year after year, we ride more smoothly, comfortably and quietly in high-performance automobiles of outstanding beauty.

And year after year, Detroit has increased the brute ruggedness and unfailing dependability which have made American cars the world's envy.

Since the dawn of the Automotive Age, National has supplied vital oil seals for the wheels, power trains, engines and accessories of cars, trucks, buses and off-highway vehicles. National is proud of this record, proud to be a part of our nation's greatest industry, proud of the faith Detroit places in the products we make.

Our pledge: still better research and manufacturing to make sure National continues to mean "tomorrow's oil seals—today!"

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California, Van Wert, Ohio

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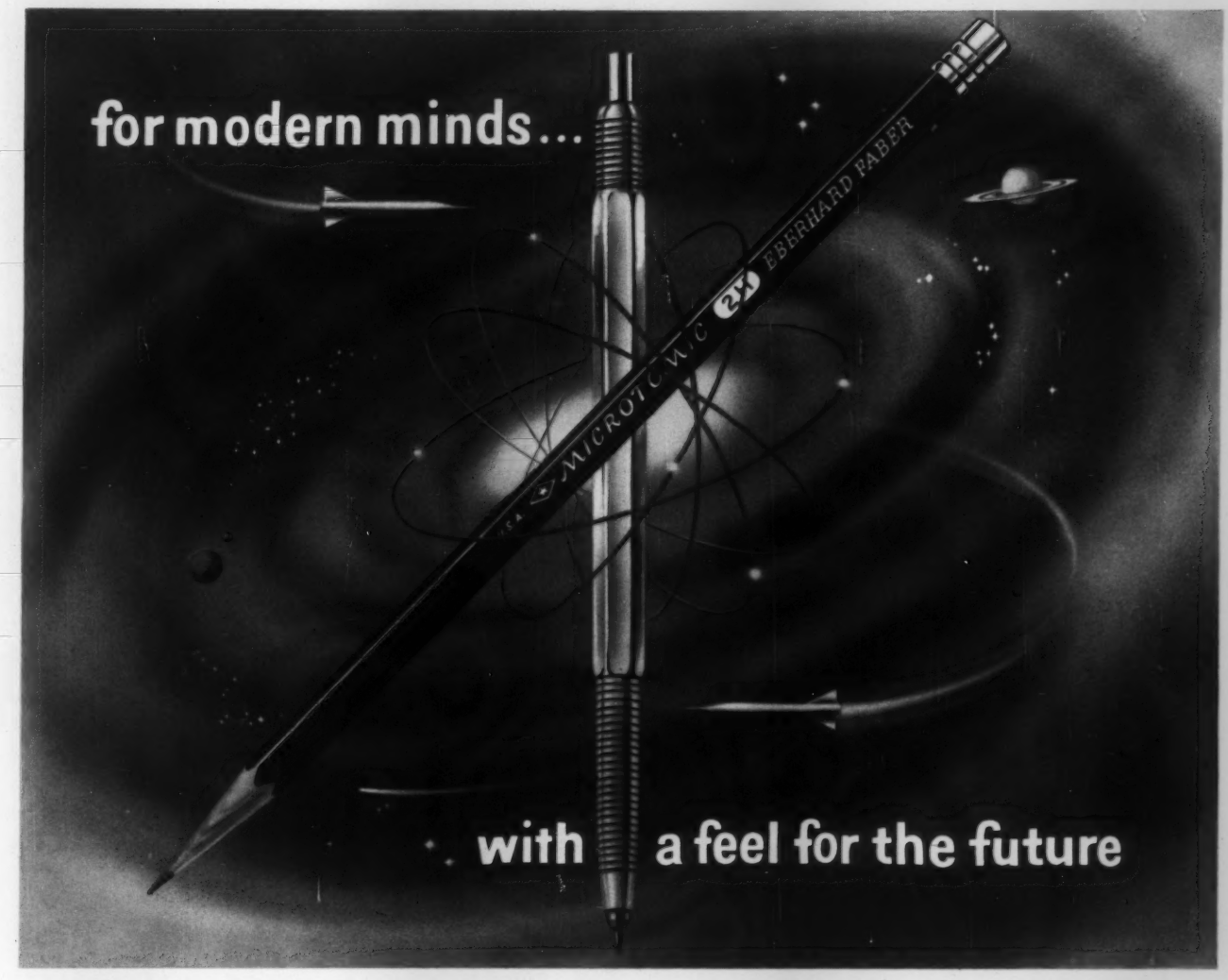
Circle 443 on Page 19→



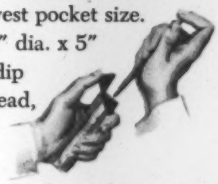
NEW IMPROVED MICROTOMIC DRAWING PENCIL—No. 600—the choice of professionals in modern streamline dress. Identified by new chrome top cap. 18 uniform degrees. Bull's eye marking to identify degree.

NEW MICROTOMIC HOLDER—No. 607—Lightweight scientifically balanced aluminum barrel with knurled finger grip. Improved positive-grip clutch with quick push button release. Colored tips identify lead degree.

THE NEW IMPROVED

MICROTOMICS

NEW ONE HAND FLIP-TOP MICROTOMIC LEAD INSERTOR —No. 6100—plastic box. Attractive vest pocket size. Holds 1 dozen drawing leads, .079" dia. x 5" long, all pointed. 17 degrees. Just flip the top and, without touching the lead, insert lead quickly into holder.



Get the feel of the future at your drawing board. Share the thrill of scientific achievement—drawing and drafting in the Microtomic Age! Sweeping style changes make Microtomics as exciting as projects you are working on. Microtomic leads take strong, keen point... reproduce clean, sharp lines, rich and black.

Since 1849 **EBERHARD FABER** puts its quality in writing

WILKES-BARRE, PA. • TORONTO, CANADA

Write on Company letterhead for further information about new improved Microtomic Pencils.

Trademarks Reg. U. S. Pat. Off.

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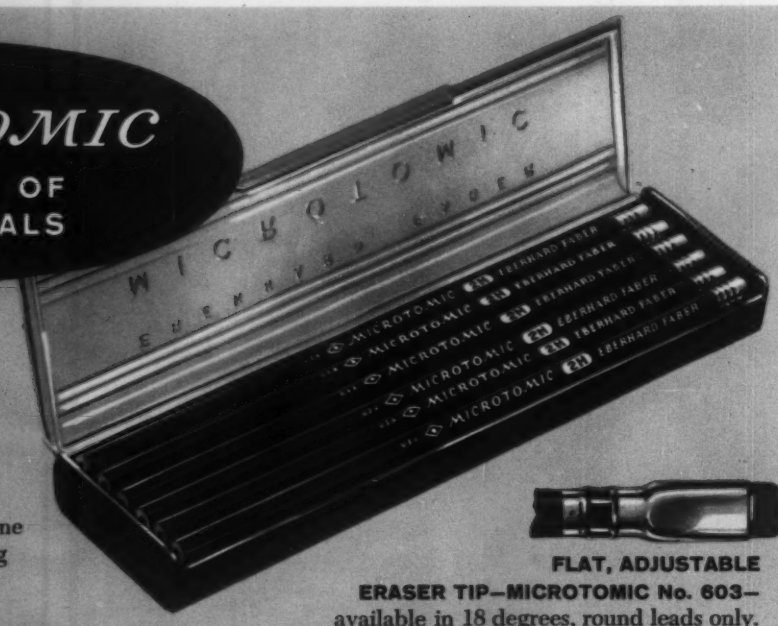
MICROTOMIC

THE CHOICE OF PROFESSIONALS



NEW MICROTOMIC PLASTIC BOX—No. 600
—handsome. Reusable. Holds one dozen MICROTOMIC drawing pencils. 18 accurate degrees.

FLAT, ADJUSTABLE ERASER TIP—MICROTOMIC No. 603—
available in 18 degrees, round leads only.

MICROTOMIC CHISEL POINT—No. 600 DRAWING PENCILS—AVAILABLE IN 6 DEGREES

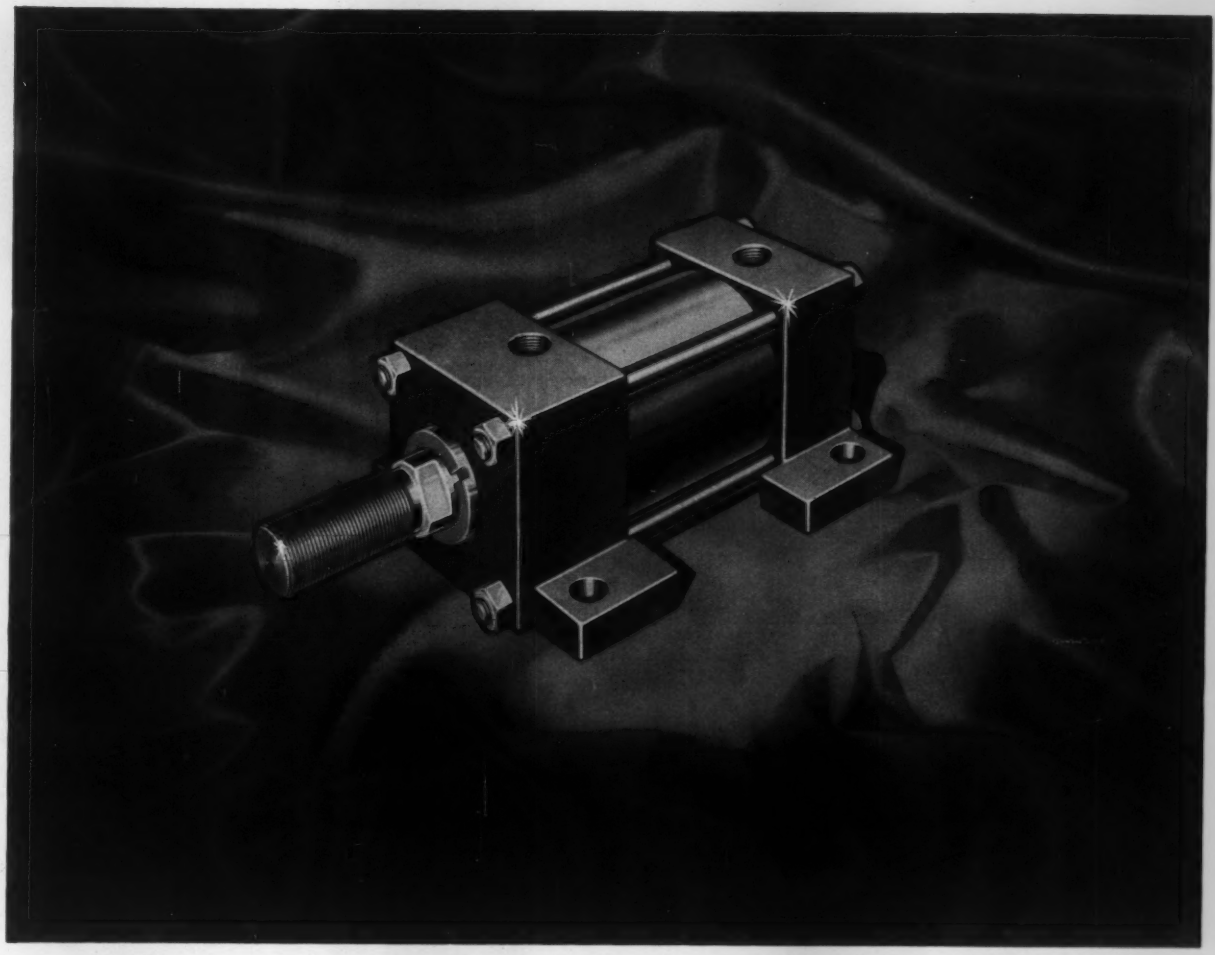
Erase without a trace with EBERHARD FABER Paper Mated Erasers

RACE KLEEN PLASTIC ERASER —No. 521—superior on special drafting and tracing papers... vellums and plastic coated stocks. Soft, gentle, extremely pliable. Contains no abrasives. Double beveled.

PINK PEARL—No. 101—favorite of artists, draftsmen and architects. Soft and pliable—won't mar paper surface. Beveled shape. Smaller size —No. 100. Convenient paper wrapped pencil shape—No. 400.

RUBKLEEN—No. 6002—the perfect all-purpose cleaner. Soft and gentle yet long-wearing. Very little crumbling. No greasy film. Extra large size—No. 6004. Paper wrapped pencil—No. 6001.

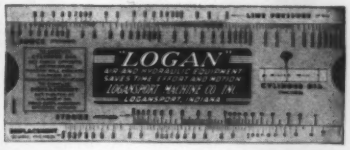
EBERHARD FABER • WILKES-BARRE, PA. • TORONTO, CANADA



Illustrated—Logan Super-Matic Cylinder Meets J.I.C. Standards

Look to Logan

the ultimate in hydraulic cylinder design



FREE SEND FOR THE "LOGAN CALCULATOR"

MEMBER: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
811 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-5-1 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
- ☐ FACTS OF LIFE
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 and 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

TO:

NAME_____ TITLE_____

COMPANY _____

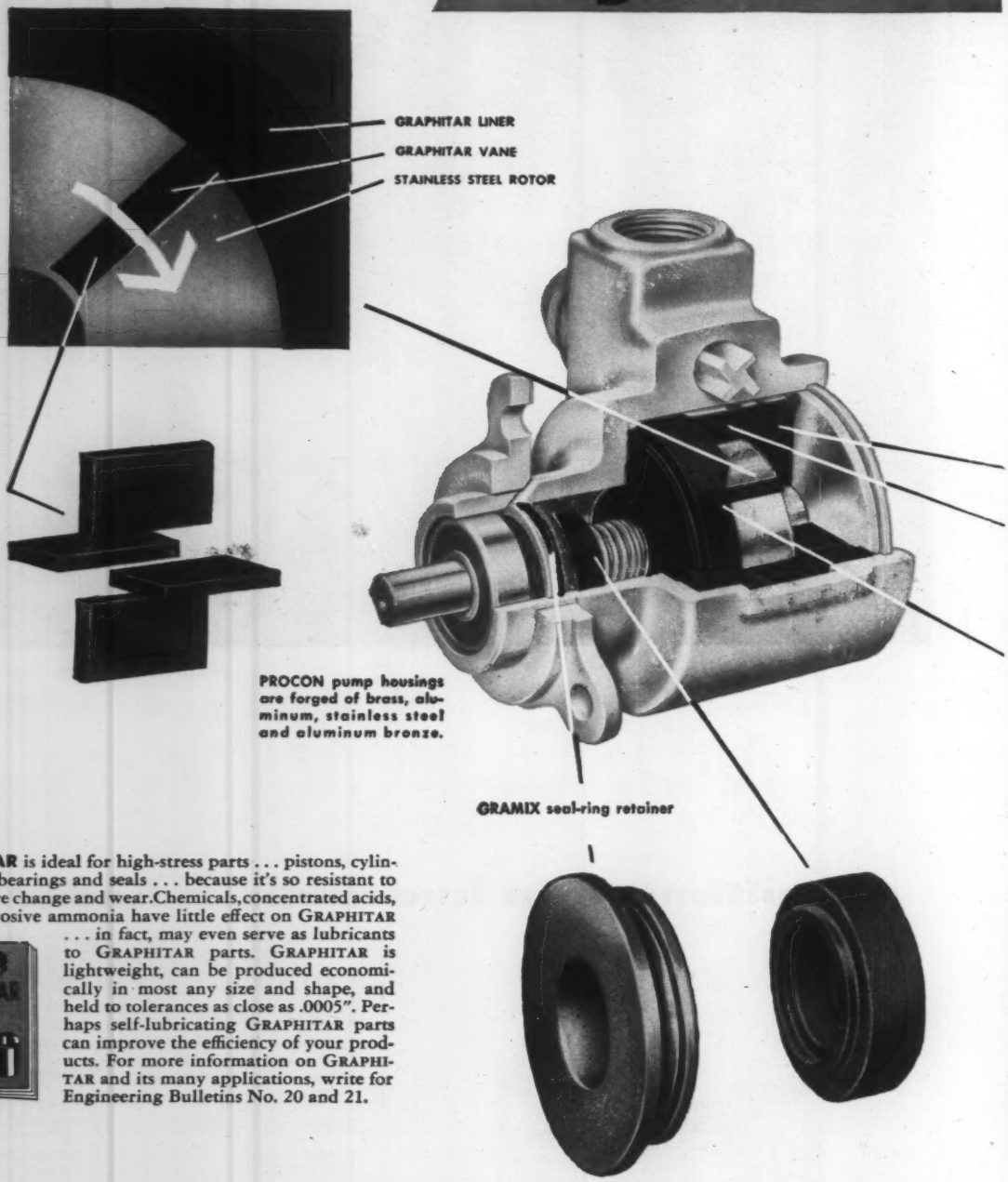
ADDRESS _____

Circle 444 on Page 19

GRAPHITAR®

(CARBON-GRAPHITE)

against


GRAPHITAR LINER
GRAPHITAR VANE
STAINLESS STEEL ROTOR
PROCON pump housings are forged of brass, aluminum, stainless steel and aluminum bronze.
GRAMIX seal-ring retainer

GRAPHITAR is ideal for high-stress parts . . . pistons, cylinder liners, bearings and seals . . . because it's so resistant to temperature change and wear. Chemicals, concentrated acids, highly corrosive ammonia have little effect on GRAPHITAR . . . in fact, may even serve as lubricants to GRAPHITAR parts. GRAPHITAR is lightweight, can be produced economically in most any size and shape, and held to tolerances as close as .0005". Perhaps self-lubricating GRAPHITAR parts can improve the efficiency of your products. For more information on GRAPHITAR and its many applications, write for Engineering Bulletins No. 20 and 21.

THE UNITED STATES

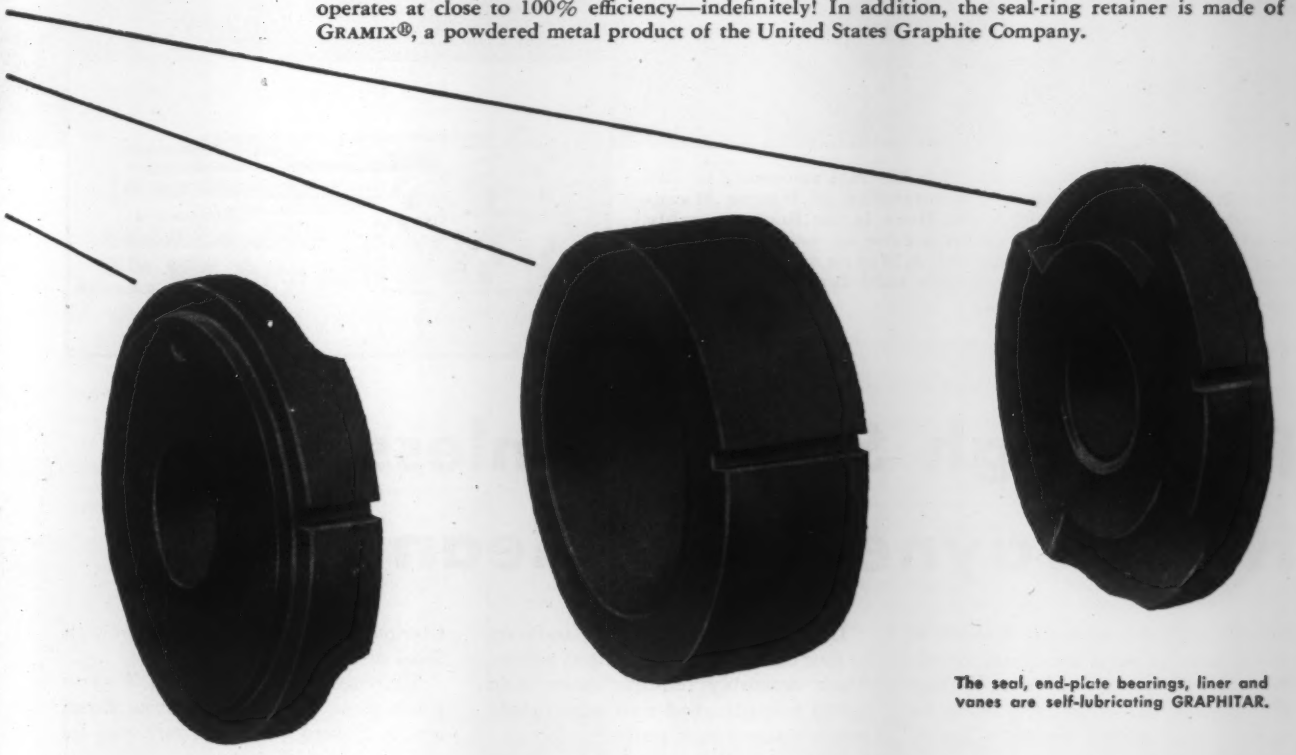
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

running GRAPHITAR®

gives PROCON PUMPS amazing performance in handling *ALL TYPES OF FLUIDS*

10¢ dropped in a beverage machine in Minneapolis actuates a pump that fills a paper cup with syrup and carbonated water; a Utah dentist flicks a switch that starts a vacuum pump used in molding dentures; in a manual training school in North Carolina, a pump circulates the ammonia in a blueprint machine.

Mixing soft drinks . . . pumping chemicals, ethyglycol, ammonia . . . even pumping hot fats at the rate of 275 gallons an hour at pressures up to 300 psi, is the every-day work of the dependable little Procon pump, manufactured by the Procon Pump and Engineering Company of Detroit, Michigan. The liner, vanes, end-plate bearings and the seal ring of this versatile, high performance pump are made of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against a GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR the self-lapping, self-lubricating and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage . . . the Procon pump operates at close to 100% efficiency—indefinitely! In addition, the seal-ring retainer is made of GRAMIX®, a powdered metal product of the United States Graphite Company.



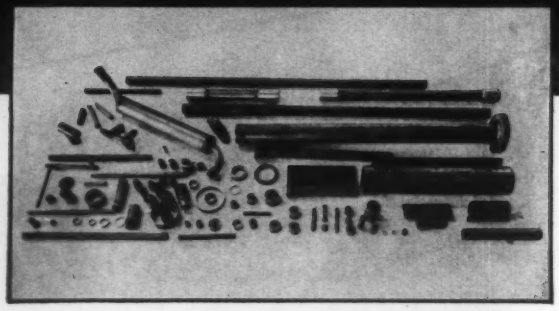
The seal, end-plate bearings, liner and vanes are self-lubricating GRAPHITAR.

R-256-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Circle 445 on Page 19



Seven-million miles of street and industrial sweeping in 700 cities have proved rugged dependability of Wayne Manufacturing Company's equipment. Here is the final assembly line in its plant. Large horizontal tube on sweeper is jack shaft housing for gutter broom drive. Wayne makes 300 parts from Pittsburgh Steel's Seamless cold-drawn tubing (see inset at right). That's how . . .

Pittsburgh Steel Seamless Tubes Help Wayne Make Clean Sweep

Nobody knows how many brooms it would take to keep the world clean. But out in Pomona, California, Wayne Manufacturing Company is ready to tackle the job with a complete line of power sweepers.

Founded only ten years ago, the Wayne Company has grown rapidly until today it produces more street and industrial power sweepers than all others in the field combined. Wayne is the only power sweeper produced by assembly-line operation.

Largest Wayne sweepers handle up to four cubic yards of debris at a time. Their assembly requires more than 1,000 complicated and accurately manufactured steel parts.

• **300 Key Parts**—Of these, more than 300 key items are fabricated from Pittsburgh Steel Company's Seamless Tubing in both carbon and alloy grades in sizes ranging from one-quarter inch to six inches in diameter. It is furnished cut to length and ready for fabrication by Baker Steel & Tube Company of Los Angeles, a Pittsburgh Steel distributor.

This service helps speed Wayne production, keeps inventories down and is typical of service rendered by all Pittsburgh distributors.

"Requirements for the parts produced from Pittsburgh tubing are exacting," says Wayne production vice-president, Roy E. Nelson. "Our sweepers are doing big jobs, many of them operating on a 24-hour schedule, and we

must have a tough, dependable product in the critical spots to take this constant heavy beating."

That is why Wayne uses Pittsburgh Seamless Tubing in critical components such as rugged axle assemblies, torque housings, drive shafts, hydraulic actuating cylinders—even small fittings.

Over the years, Wayne production men have found Pittsburgh tubing has the surface finish, close size tolerance and concentricity which minimize the amount of machining that must be done. Its uniformly high physical properties and internal soundness provide the stamina necessary for long, trouble-free service.

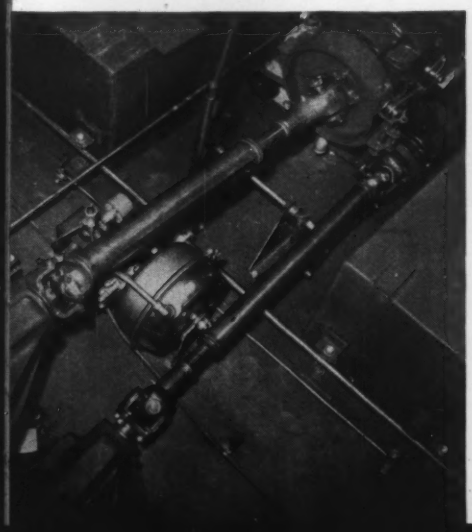
• **Ease of Fabrication**—The machinability and weldability of Pittsburgh tubing make for ease of fabrication, keep scrap losses down, and assure uniform parts—all important factors in keeping production lines moving smoothly.

As an aid to industrial good housekeeping, Wayne produces smaller power sweepers for use inside and outside plants. Its newest line is the Autoette series which includes the glamorous "Golfmobile" and the family "Cruise About." Three industrial models provide efficient transport of personnel and materials in sprawling plants.

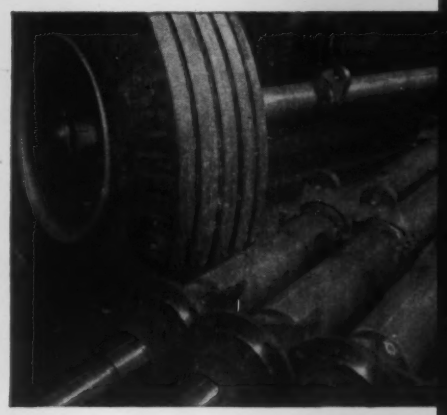
These industrial sweepers and Autoettes also depend upon Pittsburgh Steel tubing for parts in key assemblies.

Manufacturers find the uniformly high quality of Pittsburgh cold-drawn steel seamless tubing and excellent service from Pittsburgh distributors are big assets in improving products and operating efficiency. To enjoy these benefits get in touch with the representative nearest you.

Pittsburgh tubes withstand torque and fatigue in main and auxiliary drives on Wayne sweepers.



Machinability and weldability of Pittsburgh tubes are vital in making this shaft which goes into differential assembly. Short tube is welded over longer, smaller diameter tube, then machined to tolerance of .001 inch to assure perfect fit in housing.



Rugged front axle assembly of Wayne sweeper made from Pittsburgh tubes carries most of weight of machine and up to four cubic yards of debris. It must withstand road shocks and constant heavy-duty operation.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California
Chicago Tube & Iron Company
Chicago, Illinois
Cleveland Tool & Supply Co.
Cleveland, Ohio
Drummond McCall & Co., Ltd.
Montreal, Quebec, Canada
Edgcomb Steel Company
Philadelphia, Pennsylvania
Gilmore Steel & Supply Co.
San Francisco, California
Earle M. Jorgensen Co.
Perry Kilsby, Inc.
Los Angeles, California
Mapes & Sprowl Steel Co.
Union, New Jersey
Metal Goods Corporation
St. Louis, Missouri
Miller Steel Company, Inc.
Hillside, New Jersey
A. B. Murray Co., Inc.
Elizabeth, New Jersey
C. A. Russell, Inc.
Houston, Texas
Ryerson, Joseph T. & Son, Inc.
Chicago, Illinois
Solar Steel Corporation
Cleveland, Ohio
Steel Sales Corporation
Chicago, Illinois
Tubular Sales
Detroit, Michigan
Ward Steel Service Company
Dayton, Ohio

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

District Sales Offices

Atlanta, Chicago, Cleveland, Dallas, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio

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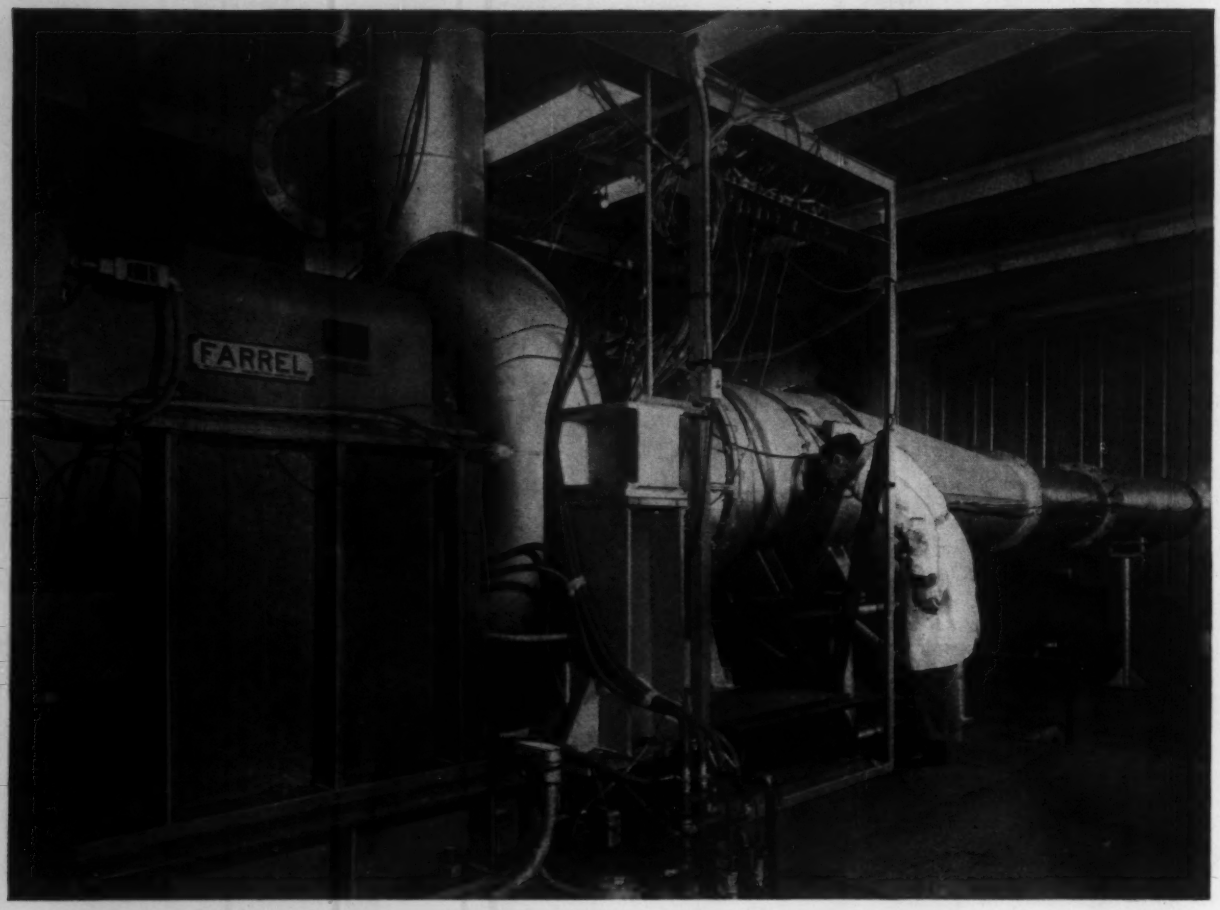


Special gear unit for Lycoming test stand provides

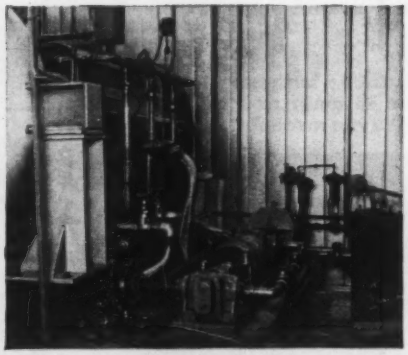
SPEEDS UP TO 27,429 RPM

This high-speed gear unit was specially designed by Farrel for use in a testing program at the Lycoming Division of Avco Manufacturing Corp. It connects a Dynamatic eddy-current coupling, driven by an Allis-Chalmers motor, with Lycoming's gas turbine compressor.

A special feature of the speed increaser is an air-actuated shifting mechanism to change the gear ratio for testing two different size compressors. With a maximum input speed of 1148 RPM from the coupling, output powers and speeds are 5000 HP at 20,111 RPM and 2500 HP at 27,429 RPM.

Other features include a horizontally locked gear train, which provides a more compact arrangement than the conventional design... herringbone gears and pinions, precision-generated by the Farrel-Sykes method... and a pressure lubrication system.

Farrel specializes in the design of gear units to meet unusual conditions of service and has the proven ability to provide the solution to your particular problem. Bulletin 451 will give you further details.



A pressure lubrication system was furnished to lubricate and cool the gears and bearings, while operating within the speed range of the test.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, Boston, Akron, Ann Arbor (Mich.), Chicago, Minneapolis, Los Angeles, Salt Lake City, Tulsa, Houston, Fayetteville (N. C.)
European Office: Piazza della Republica 32, Milano, Italy

Farrel-Birmingham®

FB-1154

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Circle 448 on Page 19→

A PREVIEW

OF A NEW SOURCE OF QUALITY STAINLESS SHEET & STRIP

Steel buyers everywhere will welcome J & L's new source of constant high quality stainless sheet and strip. The completely new stainless mill, located at Louisville, Ohio, has successfully passed through its shake-down runs and is now ready for *full* capacity production.

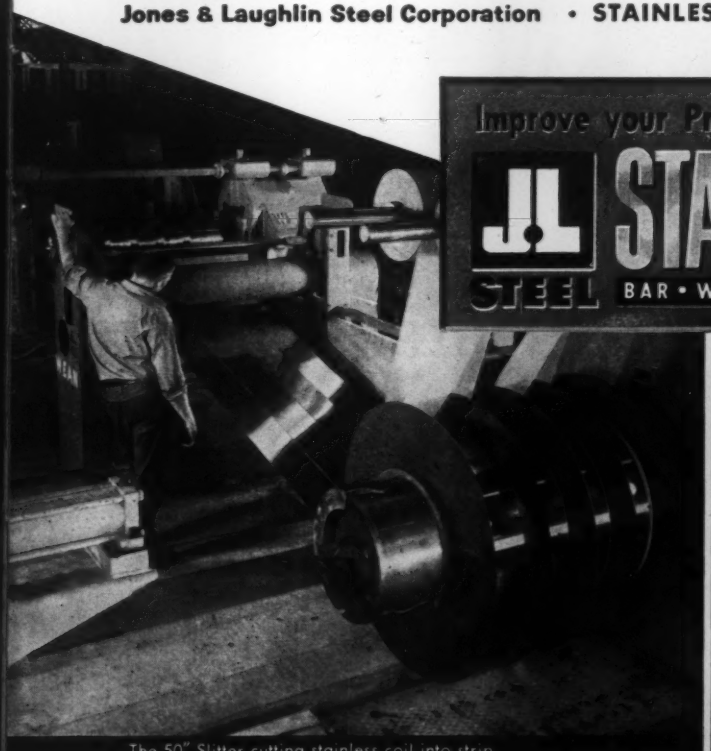
With the completion of this integrated cold rolling operation, J & L is equipped with the finest facilities in the industry to produce stainless steel strip and sheets to extremely close tolerances in widths up to 48 inches. *Write for your copy of J & L's Sheet and Strip Manual today.*

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34

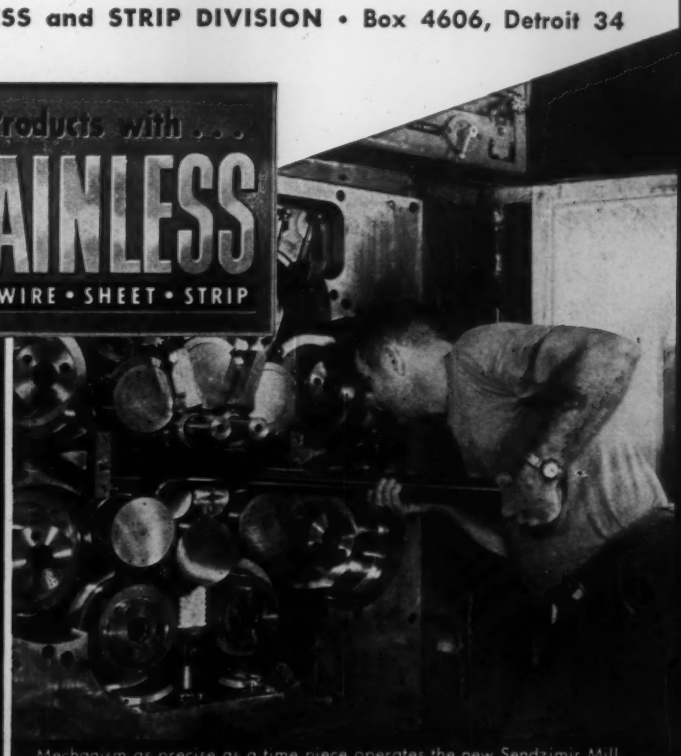
Improve your Products with . . .

J&L STEEL STAINLESS

BAR • WIRE • SHEET • STRIP



The 50" Slitter cutting stainless coil into strip

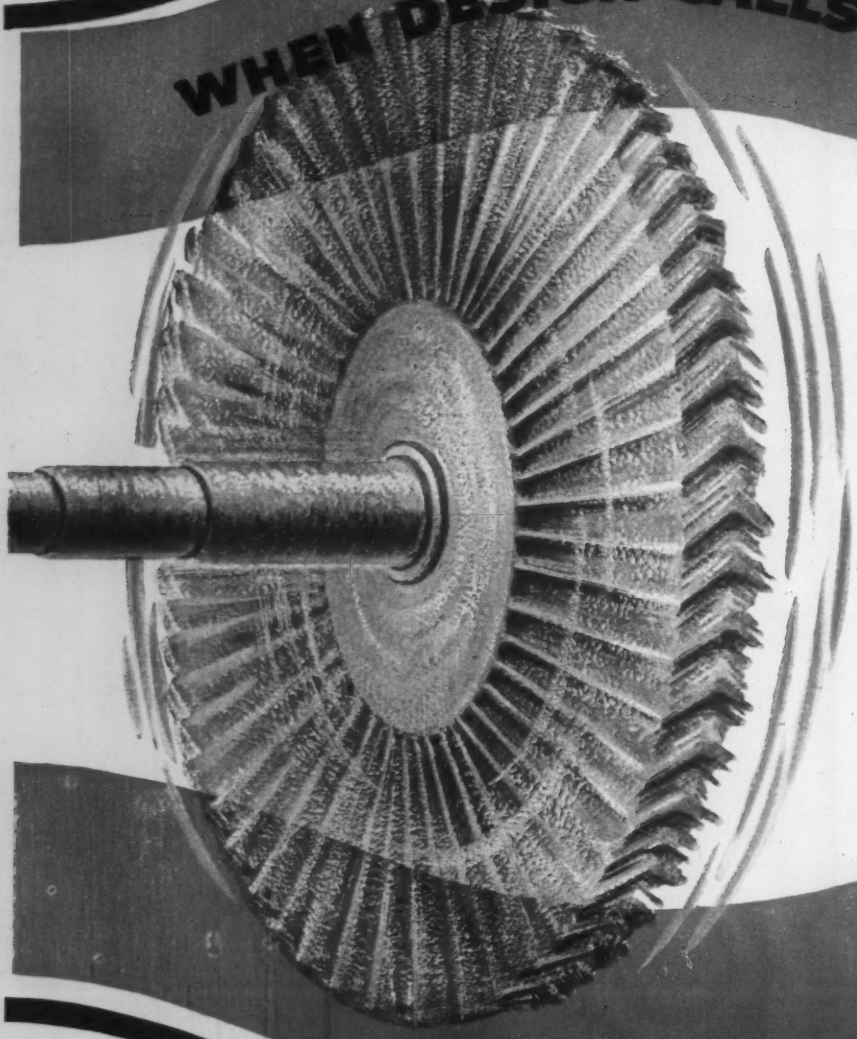


Mechanism as precise as a time piece operates the new Sendzimir Mill

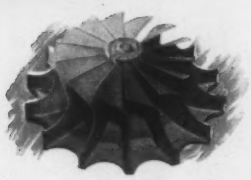
Discharge end of the cold roll anneal and pickle line

Gauge is closely checked on the Temper Mill

WHEN DESIGN CALLS FOR MASS



TYPICAL "HAYNES" INVESTMENT CASTINGS



When 1 + 1 Equals 1
This radial flow wheel now operates very efficiently as a single integral investment-casting. At one time it was produced as two castings.

5 Operations Eliminated
A welding, assembling, and 3 machining operations were eliminated when this valve disk was investment-cast as one part.

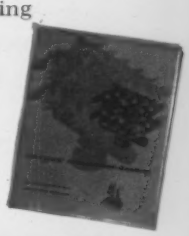
PRODUCED INTRICATE PARTS

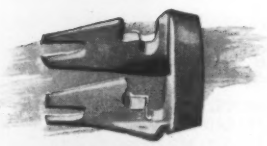
HAYNES Investment Castings *are the answer!*

Producing even one turbine wheel with intricate blading for operation at 1700 deg. F., was a tough problem not too long ago. Now integral wheels that meet the same service condition are being turned out on a mass-production basis by the HAYNES Investment-Casting method. Many of them are cast so close to specified size that only a minimum of finishing is required to put them to work.

The same facilities and engineering skills that turned this specialized operation into a routine one are ready to solve your design and production problems. The development of the HAYNES Investment-Casting process to its present high level of efficiency has enabled engineers to use design features once considered impractical. It has proven to be an economical way to mass-produce metal parts—and often the only way by which complex designs can be reproduced in a single casting.

Haynes Stellite Company has the ideal combination to produce your parts quickly and economically — complete design and tooling service, modern finishing equipment, the latest testing, inspection, and heat-treating methods, experienced personnel, and a wide range of alloys to choose from. For complete details, write for descriptive literature.





Slow, Costly Job Avoided
Producing this metering valve by machining would be slow and costly. It was mass-produced economically by investment-casting.

Improved Service Life
made possible by investment-casting this micronizer nozzle in a hard, wear-resistant alloy. The intricate design was too costly to machine.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of
Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

The terms "Haynes" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

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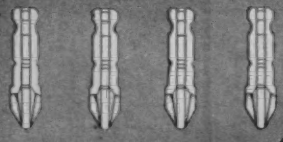
Count on *Continental* for this

2-way saving in bit costs

HY-PRO

You get 4 HY-PRO PHILLIPS Insert Bits



for the cost of 1

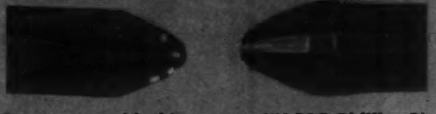
conventional bit

HY-PRO PHILLIPS Insert Bits cost only about one-fourth as much as solid bits, and there is no extra expense for re-sharpening. When a HY-PRO bit wears out, you simply replace it with a new bit . . . and restore *full* driving efficiency at negligible cost.

POWER BIT HOLDERS made in types and sizes to fit all driving tools

HY-PRO PHILLIPS Insert Bits are FORGED

Tested and proved to outlast other bits 2 to 1



Best comparable bit — HY-PRO Phillips Bit

Each bit drove the same number of screws

High strength *forged* HY-PRO Bits are production tested and proved to have an average service life *double* that of the best comparable bits. Many users report even greater margins of extra life for HY-PRO bits, often as high as 4 to 1.

Make your own tests— Compare bit life on your toughest driving jobs. Figure *all* costs. Continental Assembly Specialists will cooperate fully in conducting tests. You'll find HY-PRO Insert Bits and Holders your best buy for lasting bit economy.

Precision control with the same Phillips master tools assures uniformly accurate fit of HY-PRO Phillips Bits and HOLTITE Phillips Screw recesses. Use this proved combination for the top efficiency you need in assembly — especially with power and automatic driving equipment — to avoid downtime, rejects, and weak fastenings. For full information, write: Continental Screw Co., 461 Mt. Pleasant St., New Bedford, Mass.

Only CONTINENTAL makes BOTH PHILLIPS SCREWS and PHILLIPS BITS

MEMBER SCREW RESEARCH ASSOCIATION

CONTINENTAL

SCREW COMPANY, NEW BEDFORD, MASS.

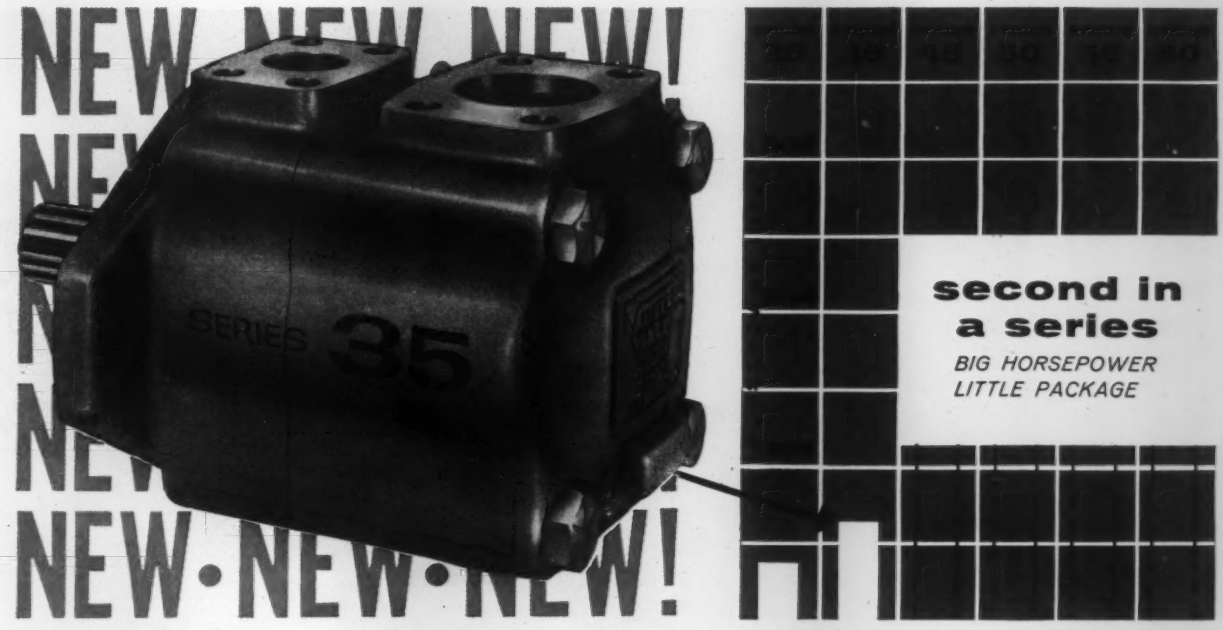
HOLTITE FASTENERS

HOLTITE PHILLIPS AND SLOTTED HEAD

WOOD • MACHINE • TAPPING
THREAD FORMING •
SEMS • NYLOK

HY-PRO PHILLIPS INSERT BITS AND HOLDERS

HY-PRO TOOL COMPANY . . . DIVISION
RESEARCH ENG. & MFG., INC. SUBSIDIARY



VICKERS® "high performance" vane pump

• high speed • high pressure • high efficiency • high service life

NEW COMPACT DESIGN . . . much more horsepower than previous pumps of the same package size.

NEW VANE CONSTRUCTION . . . positive vane tracking at all speeds assures efficient operation at increased speeds and pressures.

NEW SIZES not previously available . . . answers mobile equipment designers' need for greater hydraulic horsepower in limited space.

NEW PARTS INTERCHANGEABILITY . . . many common parts for single and double pumps (two pumps on the same shaft in one envelope). Lessens inventory requirements.

NEW 4-BOLT SAE FLANGE CONNECTIONS . . . will also accommodate user's 2-bolt flanges of the proper design.

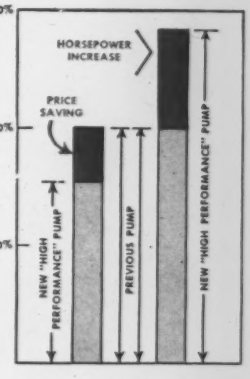
NEW 2-BOLT MOUNTING (SAE 1959 STD.).

NEW REPLACEABLE PUMPING CARTRIDGE . . . all wearing parts of pump are incorporated in one replaceable cartridge. Easy field replacement without removing pump from its mount. Cartridges available in kit form.

MORE HORSEPOWER PER DOLLAR

The graph at right makes a comparison between the new Series 35 "High Performance" Pump and a previous pump of the same delivery capacity. Note the substantial increase in maximum horsepower...over 40%! This power increase is accompanied by a price saving and by a package size reduction of almost one third!

This is the second unit released in the new complete line of "High Performance" Pumps (both single and double). The first (Series 25) is available in 12, 14, and 17 gpm sizes (at SAE rating of 1200 rpm and 100 psi). The three sizes offered in the new Series 35 pump are 21, 25, and 30 gpm. Characteristics are given in table.



Model Number	Delivery-GPM 1200 RPM 100 PSI	Delivery-GPM 2000 RPM 2000 PSI	Input Horsepower @ 2000 RPM 2000 PSI	Package Size†	Weight
2V21A-**10	20.6	32.1	42.4	L. 6 15/16" W. 5½" H. 6"	50 Lb.
2V25A-**10	24.5	38.0	49.8		
2V30A-**10	29.5	46.8	59.5		

†Exclusive of Shaft Extension and Mounting Lobes

8145

Write for new illustrated Bulletin No. M5108 for further details and performance characteristics.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION

Mobile Hydraulics Division
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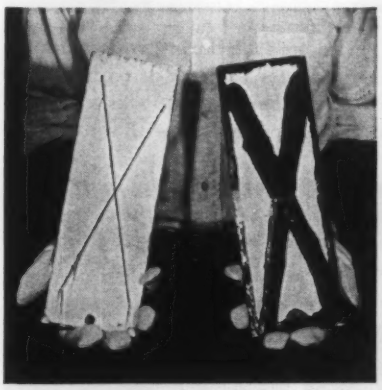
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Read the Temperature and SAVE!

New Cold Bonderite System Cuts Heat Costs Up to 70%

The temperature gauges on the input lines of a typical Cold Bonderite System installation tell the story. 40° to 75° cooler in cleaner, rinse and Bonderite than in the conventional hot phosphating installation.

And all that heat saved translates into dollars saved, because chemical costs are comparable, as is the effective protection of the coatings produced.



Salt spray tests show effectiveness of coatings produced by Cold Bonderite System.

This is a thoroughly tested and proven system. The Cold Bonderite System is in use right now in many plants in many industries. And more are changing to it as they hear about the spectacular savings.

- A large automotive plant reports savings at the rate of 40 carloads of coal per year.
- An appliance manufacturer says the Cold Bonderite System is saving 5¢ per cabinet.
- Another manufacturer shut down one of his boilers because of reduced heat requirements.
- An automotive plant is saving about 12¢ per body.

There are other operational savings besides heat when you use the Cold Bonderite System. You'll use about 25% less water. You'll save electricity because you won't need to run an exhaust fan. You'll save on maintenance. You'll cut down-time, since there's no waiting for cool-off should service be required.

There are so many benefits and advantages to the new Cold Bonderite System that you can't afford not to investigate it for *your* plant.

Call or write today!

Parker quality and Parker dependability mean that your production lines will roll steadily and efficiently.

PARKER RUST PROOF COMPANY
2193 E. Milwaukee, Detroit 11, Michigan
Tel: TRinity 5-3377

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

Since 1914—leader in the field

*Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

Republic ELECTRUNITE Mechanical Tubing is used in four locations across the top of the automatic apparatus that picks up and sets the bowling pins in place. The AMF Automatic Pinspotter is manufactured by the American Machine & Foundry Company, Brooklyn, New York.

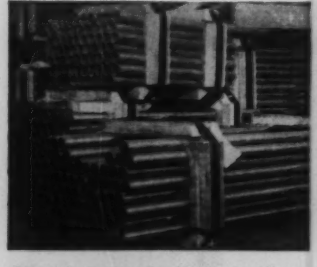
AMF . . . builds a better pinspotter for better bowling with Republic ELECTRUNITE Mechanical Tubing

On the initial order, Republic ELECTRUNITE® Mechanical Tubing saved American Machine & Foundry Company $34,000 in manufacturing their famous AMF Automatic Pinspotter.

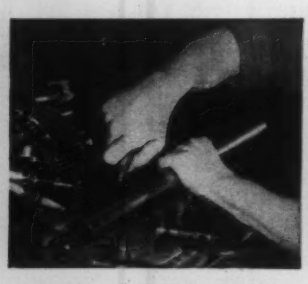
AMF had been using tubing that required a boring operation on each end of the tube and centerless grinding on the O.D.

Because Republic's ELECTRUNITE Mechanical Tubing met AMF's O.D. tolerance requirements, the company was able to eliminate the boring and grinding operations. This resulted in a savings of $15,000 in fabricating operations. Another $19,000 was saved on the cost of ELECTRUNITE as compared with the tubing used previously.

In uniformity and quality, in fabricating, in original costs, Republic's ELECTRUNITE Mechanical Tubing can save you time and money, too! Call your Republic representative, or write today.

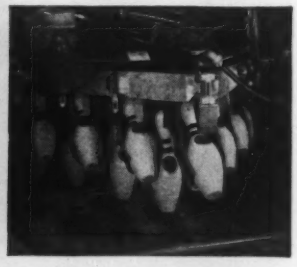


Republic ELECTRUNITE Mechanical Tubing is delivered, cut to length, ready for fabricating. ELECTRUNITE Tubing is "electrically welded" resulting in built-in uniformity.



Slots to hold spotting cups in place are cut into ELECTRUNITE Tubing by machine. Concentricity of the ELECTRUNITE assures easy fabrication and smooth mechanical operation.

Drilling and cutting complete, the ELECTRUNITE Tubing is ready for assembly. Lightweight ELECTRUNITE offers uniform wall thickness, strength, ductility for greater serviceability.



Sensitivity in setting off-spot pins is the result of design and engineering, highest quality workmanship, and highest quality materials, such as Republic's ELECTRUNITE Tubing.

REPUBLIC NYLOK® FASTENERS SAFEGUARD PERFORMANCE SPECIFICATIONS. Republic fasteners are used extensively on Gemco Rotary, Reel, and Riding Power Lawn Mowers. Inset shows blade assembly securely locked to engine shaft with Nylok Cap Screw. An added advantage of Republic Nylok Bolts and Cap Screws is their ability to seal against fluid escape when wrenched tight. Nylon pellet in bolt body blocks flow of fluid along helical threaded path. Send for data.

REPUBLIC MANUFACTURERS' COARSE WIRE to meet every production need. Box Binding and Stapling, Brush Handle, Chain, Garment Hanger are only a few of the qualities regularly produced. Large tonnages are shipped to manufacturers of fan guards, wire partitions, concrete reinforcing specialties, plated shelves, racks and grilles, and numerous other products. Republic wire metallurgists are available to help you in solving production problems. Write today.

REPUBLIC HIGH STRENGTH STEEL IMPROVES SERVICE LIFE for many types of equipment. In the bottom of this conveyor, for example, it provides excellent resistance to abrasion and corrosion. Far less frequent replacement is required as compared with a bottom made of ordinary steel. And, its high strength-to-weight ratio allows use of lighter gages. Send for details.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. MD-6300-R
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send information on the following Republic products:

☐ REPUBLIC ELECTRUNITE Mechanical Tubing
☐ Republic Manufacturers' Wire ☐ High Strength Steel
☐ NYLOK Bolts and Cap Screws

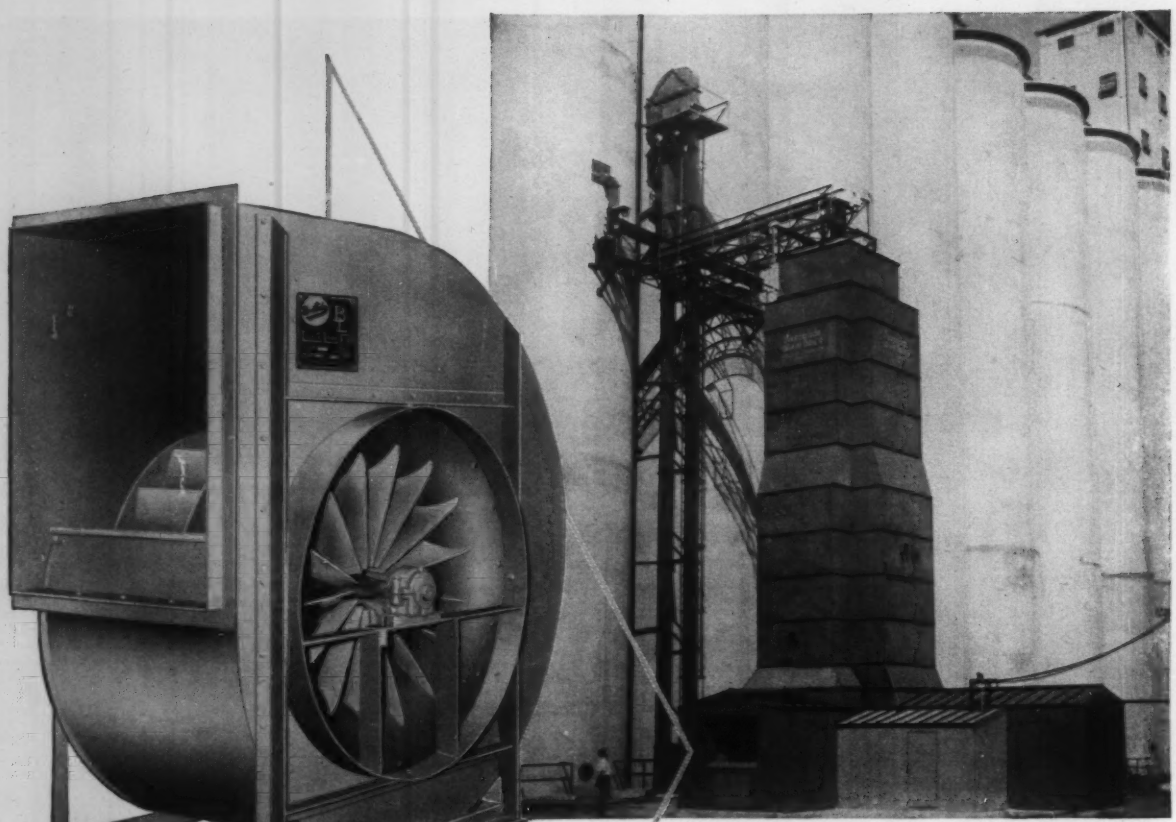
Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 453 on Page 19



Aeroglide® Grain Drier Installation

"Buffalo" Type "BL" Fan of the Type Used in Aeroglide® Grain Driers.

WHY DESIGNERS OF AEROGLIDE® GRAIN DRIERS SELECTED 'BUFFALO' FANS

Aeroglide® Grain Driers are doing an outstanding job in scores of installations throughout this country and abroad. A major feature of the Aeroglide® Drier is the induced draft principle. This has proved most economical, and results in highest quality dried grain. (Corn, oats, wheat, buckwheat, flax, barley, soybeans, lupine and milo.)

Heart of this unique drier is the fan which provides the induced draft. It is logical that Aeroglide® should specify "Buffalo" Fans for this important job. High fan efficiency is required, plus utmost dependability. The "Buffalo" Type "BL" Fans used in Aeroglide® Grain Driers are living up to their world-wide reputation for quiet, economical, reliable, efficient performance.

You can rely on this same high degree of performance and durability in *all* "Buffalo" Fans. The broad and varied line of "Buffalo" Fans of every type and size assures just the *right* fan to perform best on *your* jobs. And, at no obligation, you enjoy the services of competent, experienced "Buffalo" Engineers to help you specify the proper air moving equipment.

"Buffalo" Fans can be doing a *better* air moving job for *you*. Phone your nearest "Buffalo" engineering representative, or write direct for full information.

Every "Buffalo" Fan brings you the "Q" Factor — the built-in QUALITY which provides trouble-free satisfaction and long life.

BUFFALO FORGE COMPANY

BUFFALO, NEW YORK

Buffalo Pumps Division, Buffalo, N. Y.
Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT • EXHAUSTING FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING

Circle 454 on Page 19

Circle 455 on Page 19→

d'Arazien

Alcoa puts the metal where you want it

Before you read on, blink your eyes. In the time it took to do that, this man has produced an entire automotive grease gun body—complete with external ribs; solid end; smooth, seamless interior; and go-to-market external finish.

Sound too easy? No! We can make round, oval, square and irregular parts the same way. Finished parts—with the strength of forgings—with tolerances down to plus or minus 0.005″—with a smooth, corrosion-resistant finish of about 125 microinches. A clear case of putting the metal where *you* want it. The cost of tooling for impacts is surprisingly low, too. A good rule to remember is that virtually any closed end or tubular design should be considered as an Alcoa® Impact.

In impacts, as well as forgings, castings, extrusions and screw machine parts . . . Alcoa puts the metal where you want it. A call to Alcoa can mean fewer rejects or ingenious design solutions . . . less waste in production or a product that sells faster. Start now; write for Alcoa Up-to-Daters, a file of design tips on Alcoa Engineered Products. Aluminum Company of America, 1999 Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM

Alcoa puts the metal where you want it — in castings, forgings, extrusions, screw machine parts and impacts.

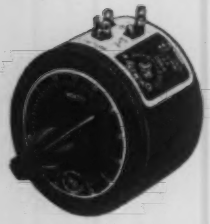
ALCOA THEATRE
FINE ENTERTAINMENT
ALTERNATE MONDAY EVENINGS

Now — 3 New

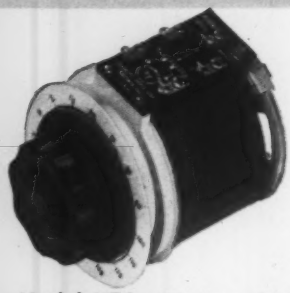
OHMITE® Variable Transformers

V.T.

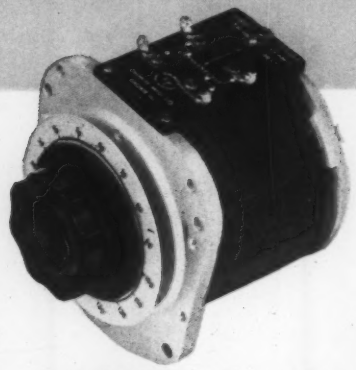
Enclosures . . . Tandem Assemblies



Model VT2—1.5 Amp. Max. Output Current at any Contact Setting (120 V. Input). Load Rating: 0.20 Kva. Angle of Rotation: 320°. Standard Mounting: For panels up to ¼", by ⅜"-32 Bushing and Nut. Weight: 2.5 lb. Pat. No. 2,790,882.



Model VT4—3.5 Amp. Max. Output Current at any Contact Setting (120 V. Input). Load Rating: 0.49 Kva. Angle of Rotation: 324°. Standard Mounting: Table mounting or for panels up to ⅜", by 3 screws ¼"-20 (or 4 screws with Adapter Plate). Weight: 5.25 lb.



Model VT8—7.5 Amp. Max. Output Current at any Contact Setting (120 V. Input). Load Rating: 1.0 Kva. Angle of Rotation: 324°. Standard Mounting: Table mounting or for panels up to ⅜", by 3 or 4 screws ¼"-20. Weight: 10.25 lb.

Industry's Most Advanced Design! Ohmite VT continuously adjustable autotransformers provide convenient, smooth, wide-range voltage control for alternating current power circuits. Units deliver adjustable voltage, continuously variable from zero to (a) line voltage or to (b) 10% or 17% above the primary line voltage — provide excellent voltage regulation — voltage remains practically constant at any setting, regardless of load fluctuations.

Model VT2 has higher current and kva capacity than equivalent size transformers. Current is carried from contact brush to a copper-graphite slip-ring. A coil spring provides uniform pressure at this point; a long, spring-steel arm, insulated by a ceramic hub, provides pressure for the carbon contact. Positive internal stops eliminate possibility of damage to contact arm and brush due to application of torque at rotation limits.

Model VT4, like the VT2, has higher current and kva capacity than equivalent size transformers. A low resistance path is assured by a pigtail directly connected from contact brush to the "slip-ring." Contact heat is efficiently dissipated by the circular contact carrier plate.

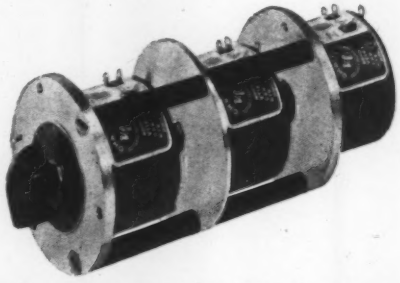
Tapped holes in the plate provide for 3-hole mounting. The mounting holes in the base plate, or in separate adapter plate (when specified), provide for 3- or 4-hole mounting interchangeable with other similar transformers. The contact brush is readily accessible for service or replacement. The insulated shaft can be conveniently adjusted for either table or back-of-panel mounting.

Model VT8 possesses all the features of the VT4 and has a unique base plate which permits 3- or 4-hole mounting interchangeable with other standard types.

Transformers can be provided with shafts of special length, with rear extension, special flats, etc. Bushings for VT2 can be made for special panel thicknesses. A "Micro-Switch" or similarly sensitive switch can be provided mounted on the transformer. VT Transformers can be provided with a motor drive for remote control or servo operation.

Write on company letterhead for new Catalog and Engineering Manual 58.

Enclosures can be provided for portable or fixed use (back-of-panel or surface mounting). Portable housings may have a line cord, a receptacle, pilot light, fuse, or circuit breaker as specified.

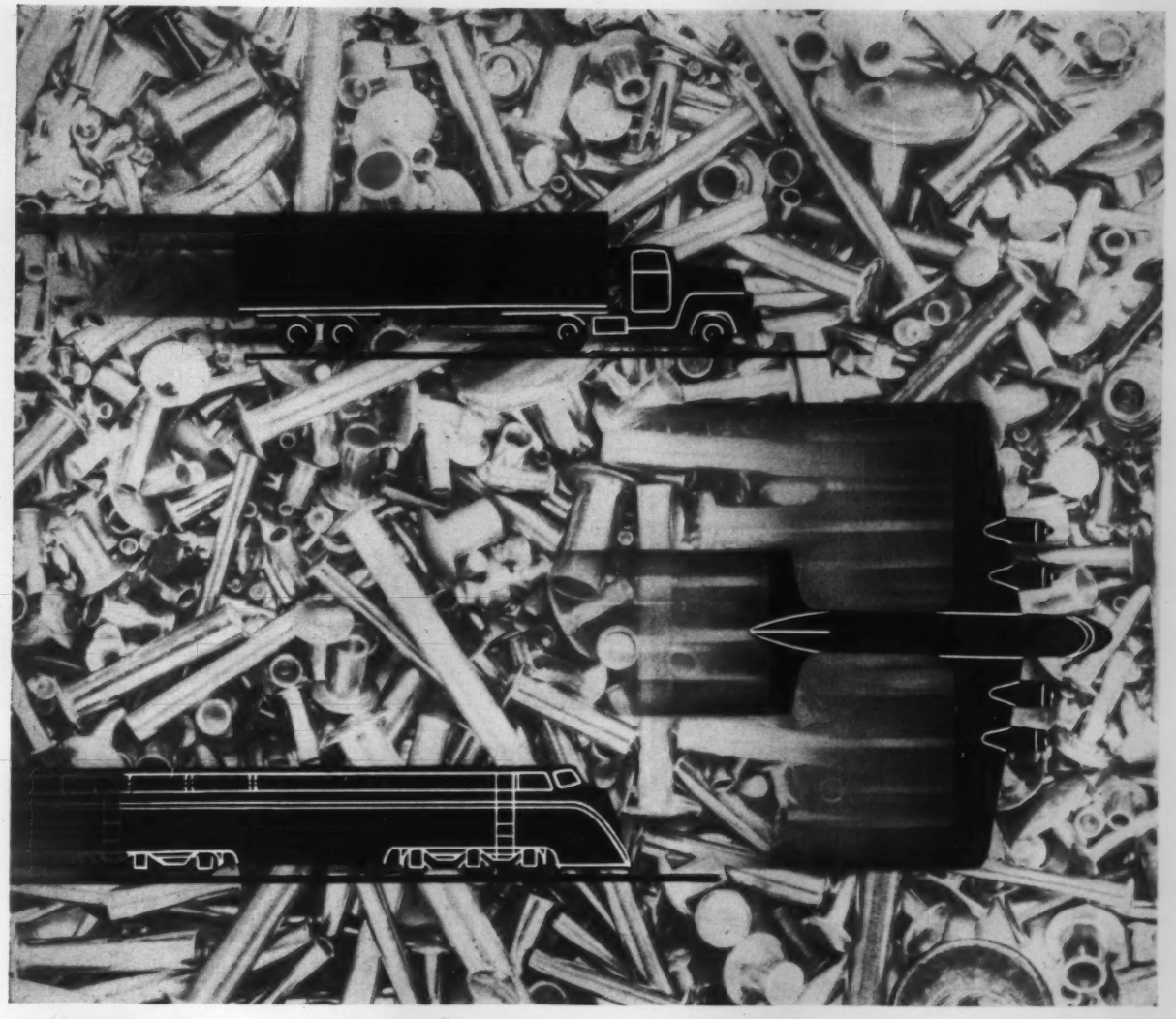


Tandem Assemblies VT Variable Transformers are ganged by means of plates and spacers. The shafts are joined by special couplings for Model VT2; a throughshaft is used for VT4 and VT8. Special tandem assemblies of VT Transformers and Ohmite Rheostats can be made as required.

OHMITE MANUFACTURING COMPANY 3618 HOWARD STREET SKOKIE, ILLINOIS

RHEOSTATS RESISTORS RELAYS TAP SWITCHES R.F. CHOKES VARIABLE TRANSFORMERS TANTALUM CAPACITORS

Circle 456 on Page 19



NEW INVENTORY SYSTEM SPEEDS RIVET DELIVERIES

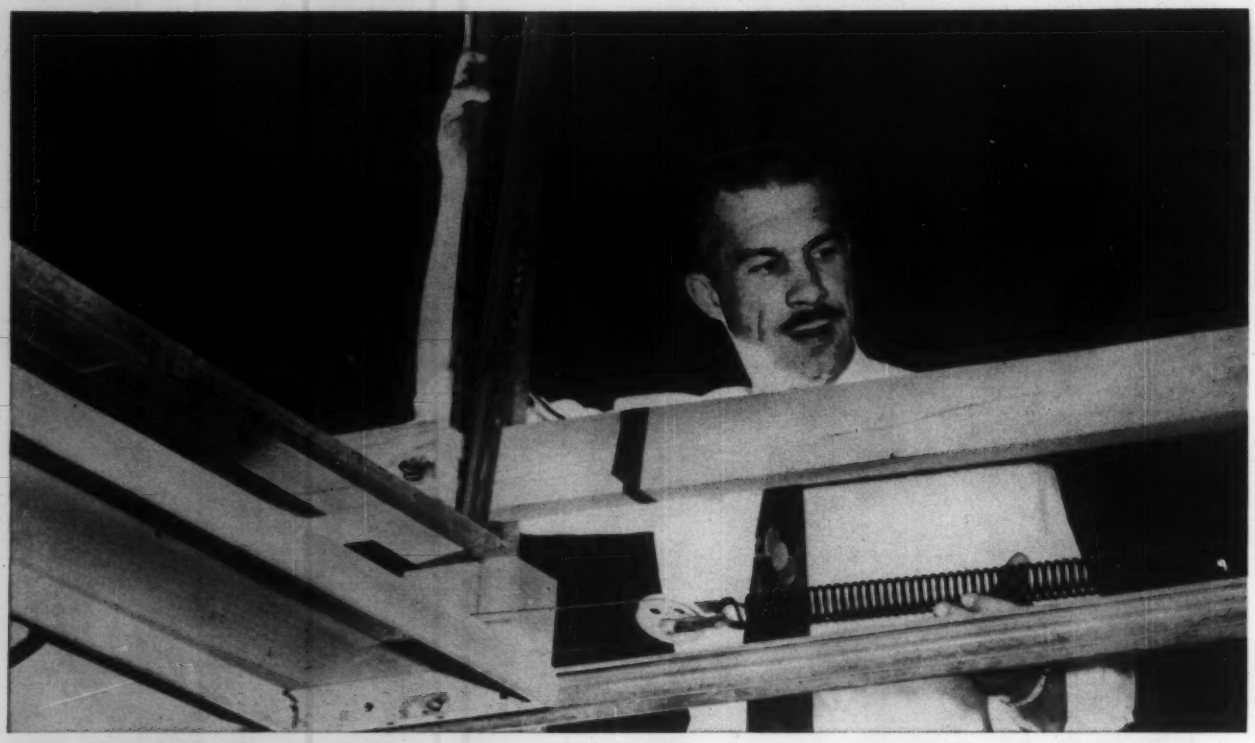
Judson L. Thomson now keeps 500 million rivets in stock to meet your everyday needs

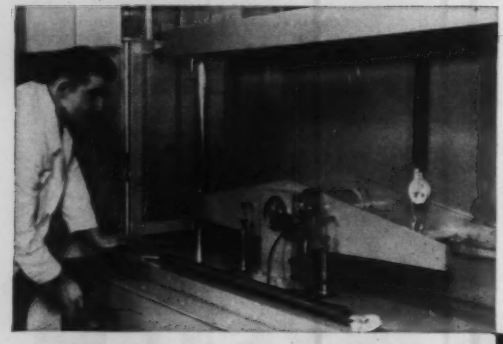
This new system keeps our inventory high so *you can keep yours low*. It's based on the 800 most-used standard rivets. It's backed up by productive capacity exceeding 20 million rivets a day. When your order comes in, semi-finished rivets are quickly finished to your specifications . . . and delivery is geared to *your production schedules*.

Next time you need rivets, order from Thomson because . . .
TWENTY MILLION A DAY — SPEEDS RIVETS YOUR WAY.

JTL JUDSON L. **THOMSON** MFG. CO., 39 Sawyer Rd. WALTHAM 54, MASS.

Circle 457 on Page 19

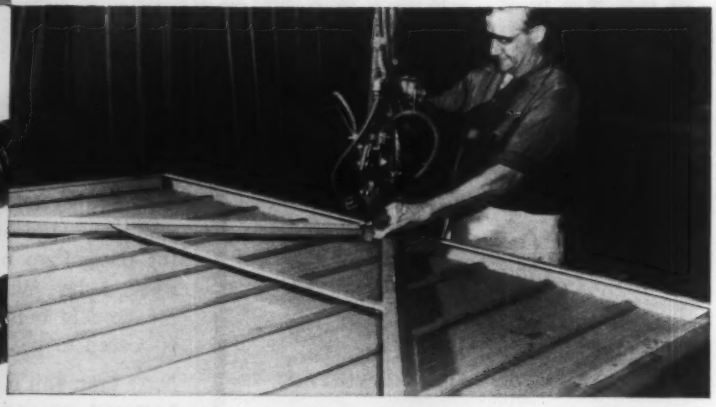




At Steel Door . . .

USS American Springs thanks to AS&W

In the American Steel & Wire Fatigue Laboratory, a technician runs tests on a USS American Spring, designed for Steel Door use. On the basis of this test a change in hook design was recommended to give longer spring life.



A Steel Door workman assembles a Berry One-Piece Door. This company uses steel exclusively for all doors because of its many consumer advantages. Steel is stable, won't warp or swell. Steel doors need less maintenance and preparation, and steel doors are easy to operate.

This close-up shows the improved hook on the extension springs supplied by American Steel & Wire for the Steel Door overhead garage doors.

stretched 31,000 times and still going strong...

Spring Engineering Research Service

The Steel Door Corporation, Birmingham, Michigan, is the world's largest manufacturer of residential garage doors. For the production of these doors they use about 150,000 USS American Springs every year. Steel Door asked American Steel & Wire for a statistical evaluation of the fatigue life of the extension hook-type springs they use. The AS&W Spring Engineering Research Service tested these springs in the Fatigue Laboratory and recommended a change in hook design.

So successful was this design change that the life of the springs has been materially increased. At the Steel Door plant a cycle test was set up using USS American Springs on an overhead door. At the present time these springs have completed over 31,000 cycles without showing any sign of failure. This is the equivalent of 25 years of normal usage.

Mr. Ralph Qualman, Advertising Director and Service Manager, says: "It is extremely important that the springs—especially those used on sectional doors where the strain is greatest—have proper tension and a long life. American Steel & Wire supplies Steel Door with springs that meet their engineering specification and life expectancy."

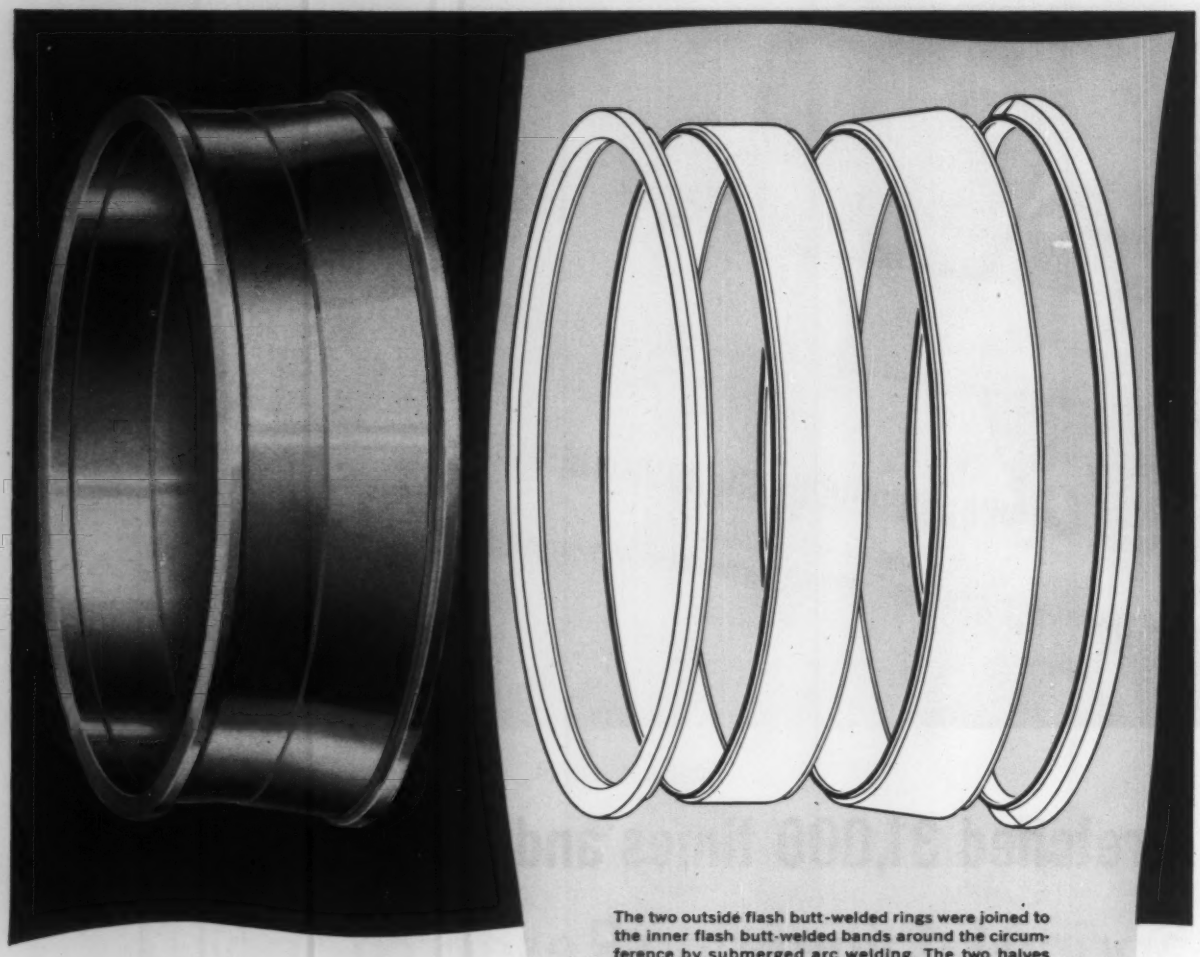
If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general offices in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steel—from steel chemistry through product application—to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, General Offices: Rockefeller Building, Cleveland 13, Ohio.*

USS and American are trademarks

American Steel & Wire Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

Circle 458 on Page 19



The two outside flash butt-welded rings were joined to the inner flash butt-welded bands around the circumference by submerged arc welding. The two halves were then welded together to complete the assembly.

Tricky

Welded Fabrication Cuts Cost of this Precision Assembly

To reduce material and machining time, Amweld® produced this 340 lb. turbine casing as a 4-piece welded assembly. Four flash butt-welded rings were joined together by submerged arc welding. The material used was AMS-5723, a high temperature alloy. Amweld's know-how, gained from fabricating hard-to-weld metals, enabled their engineers to develop a satisfactory technique for producing these aircraft components in quantity. The result — assemblies which met all specifications — and a substantial reduction in cost for a large manufacturer of aircraft engines.

If you would like to obtain complete information on the capabilities of American Welding and how we can be of assistance to you — phone or write today. Our local representative will be happy to call and discuss your requirements.

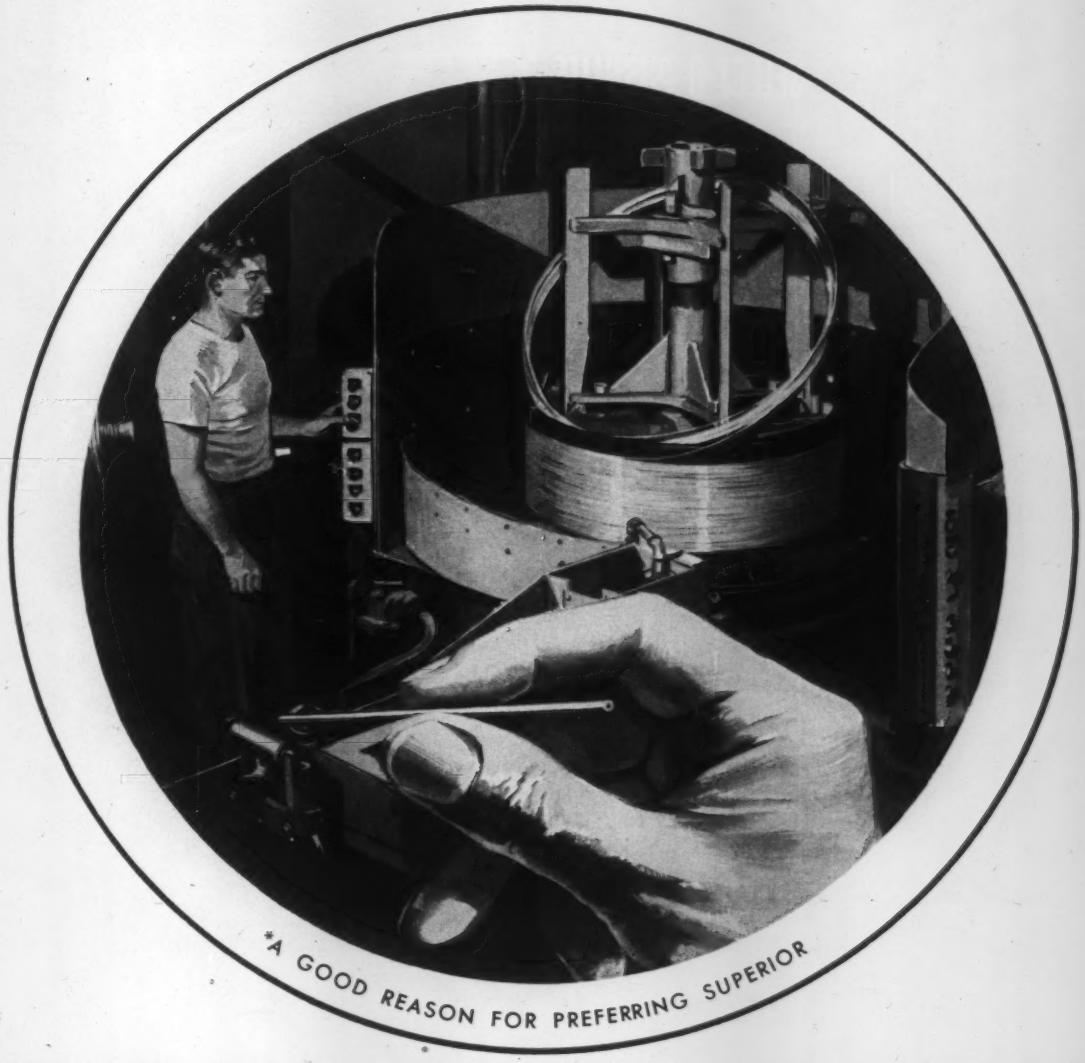
HOW AMWELD® FLASH BUTT-WELDED RINGS ARE PRODUCED. Write today for new 20-page illustrated booklet.

THE AMERICAN WELDING & MANUFACTURING CO.

130 Dietz Road • Warren, Ohio

AMERICAN WELDING

Circle 459 on Page 19



New—capillary tubing in 3000 ft. lengths for industrial instrumentation

Improved bore uniformity, broader size range, flow tested to your specifications

To meet the demands of modern instrument design and automated fabrication, Superior is now offering seamless capillary tubing in lengths up to 3000 ft. It is available in nine different materials from select-quality raw stock, including stainless steel, carbon steel, nickel and nickel alloy.

Scrupulous care in manufacture results in a finished product that is bright and scalefree, with an extremely smooth, uniform bore. The tubing is easy to weld, braze or solder. ODs range up to 3/16 in.—IDs from .004 to .040 in. maximum.

When you order capillary tubing by Superior you are assured that your specifications will be met. In addition to 100% dimensional, pressure and finish inspections, we also can test lengths for flow rates with the latest equipment when specified. Rates can be varied from 5 to 3700 cc per min.

More information on Superior's improved capillary tubing products is yours for the asking. Send coupon today.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to 5/8 in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. RAymond 3-1331

SUPERIOR TUBE COMPANY
2010 Germantown Ave., Norristown, Pa.
Send me a copy of new Data Memorandum 11, on capillary tubing.

Name_____ Title_____

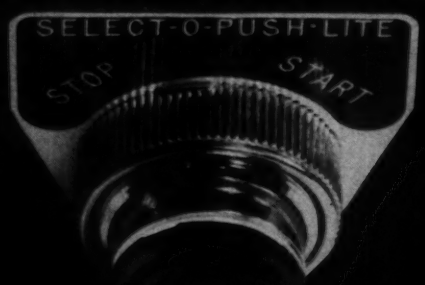
Company_____

Street_____

City_____ Zone____ State_____

Circle 460 on Page 19

SELECT-O-PUSHLITE



ANNOUNCING

TWO NEW SPACE-SAVING, COST-SAVING WESTINGHOUSE PUSHBUTTONS

Either of these two new pushbutton designs can replace three separate units on your control panel! Save you up to 60 percent on panel space!! Save you 25 percent on initial cost!!!

Both function as a start button, a stop button and an indicating light—all in one compact, oiltite selector unit!

SELECT-O-LITE is a low-voltage *release* unit which is operated by a mere twist of the button—to on-off, start-stop—any combination you desire.

SELECT-O-PUSHLITE is a low-voltage *protection* device which operates only when the button is turned, *then pressed*—an added safety feature for critical operations.

Select-O-Lite and Select-O-Pushlite are available from Westinghouse—the same company that first brought you Pushlite and Push-To-Test pushbuttons. For detailed dimensions and ordering information, please contact your nearby Westinghouse sales office. Or write: Westinghouse Electric Corporation, Standard Control Division, Beaver, Pennsylvania. J-30303

YOU CAN BE SURE...IF IT'S **Westinghouse**

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS," CBS TV MONDAYS

Circle 461 on Page 19

WHAT MATERIAL

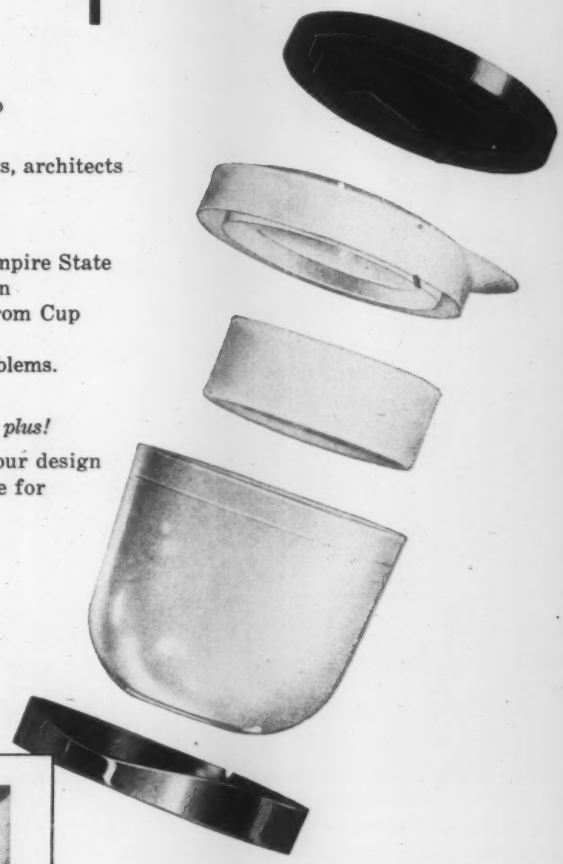
DRY CHOCOLATE DISPENSER. To meet special qualities in esthetics and strength, BAKELITE TMDB-5161 is used in molding the precision main parts of the new "Carnation" hot cocoa mix dispensers for use in the restaurant field. The high heat-and-impact resistance of this styrene material makes it completely washable, and insures accurate, trouble-free service.

Molded by Field Manufacturing Corp., Santa Monica, Calif.

IS ALWAYS NEW?

BAKELITE
BRAND
PLASTICS

. . . offering new freedom in design . . . and cost . . . and functional advantages!



It continually appears in *new* compounds and forms to meet new specifications.

It encourages the creative talents of design engineers, architects and interior and industrial designers.

You *know* the answer—*BAKELITE* Brand *Plastics.*

From the coatings on TV towers atop New York's Empire State Building to undersea oil rigs . . . from the packages on supermarket shelves to molded appliance parts . . . from Cup challenger yacht hull sealers to jet plane controls . . . *BAKELITE* Brand *Plastics* are solving new design problems.

And *BAKELITE* Brand *Plastics* almost invariably offer cost, production and functional advantages *as a plus!*

BAKELITE COMPANY WILL HELP YOU: Whatever your design area, no matter how unusual the qualities you require for forming, strength, rigidity, flexibility, insulation, corrosion resistance—explore the proven advantages of *BAKELITE* Brand *Plastics* and *Resins.* The material that's new all the time!

Technical representatives with years of training and field experience are available to discuss your special design problems. Write Dept. KW-51D.

THIS NEW AND DIFFERENT BLENDER, with separate compartments from which liquids are automatically mixed when poured, is easy to clean and hard to break. BAKELITE C-11 acrylonitrile-styrene-copolymer is used for the outer container, for strength, chemical resistance and low cost. The lid is BAKELITE Brand Styrene Plastic. Molded by Avsco, Inc., Excelsior Springs, Missouri.

Products of UNION CARBIDE *Corporation*

BAKELITE COMPANY, *Division of Union Carbide Corporation,* 30 East 42nd Street, New York 17, N. Y.

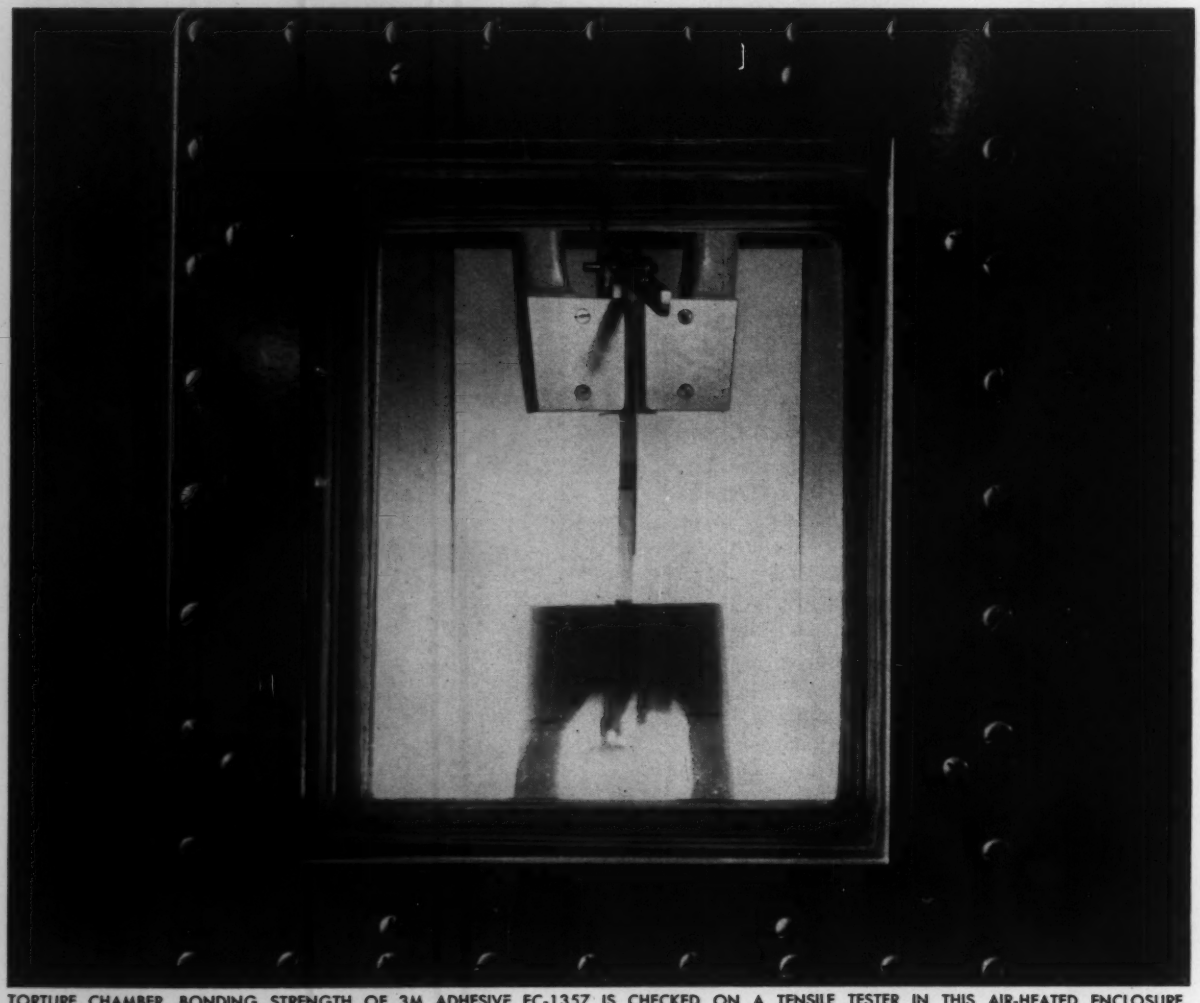
The terms BAKELITE and UNION CARBIDE are registered trade-marks of UCC.

5051

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Toronto 7, Ontario.

Circle 462 on Page 19

Rugged 3M sandwich adhesive EC-1357 holds 315 psi at 200° F.



TORTURE CHAMBER. BONDING STRENGTH OF 3M ADHESIVE EC-1357 IS CHECKED ON A TENSILE TESTER IN THIS AIR-HEATED ENCLOSURE.

The two metal strips in this tug-of-war are bonded by a tough, heat-resistant 3M sandwich adhesive—EC-1357. On the tensile tester, under a dynamic loading of ½ inch per minute . . . and at searing temperatures as high as 200° F. . . . EC-1357 withstands a stress of over 300 psi.

Rugged grip . . . you bet! But more than that, because it is dark colored, EC-1357 dries faster under infrared heat, and you cut production costs by pre-drying for maximum immediate strength—or cold-bonding on a cold press or nip roller for fabricating at room temperature.

Its remarkably high resistance to moisture, high and low temperatures, and weathering make EC-1357 ideal for installations where climatic changes are sudden and severe. And EC-1357 is easy to spray-apply. Greatly reduced cobwebbing insures better surface-wetting for far better adhesion. And you save materials!

3M also offers EC-1368, a light colored version of EC-1357 which provides the same cold-setting, high strength bond.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

For full details contact our branch sales office near you. There are 19 located in principal cities throughout the United States ready to assist you in technical problems. Six plants provide local service for faster delivery. For free illustrated literature, write: A., C. & S. Division, 3M, Dept. C-11, 900 Bush Ave., St. Paul 6, Minnesota.

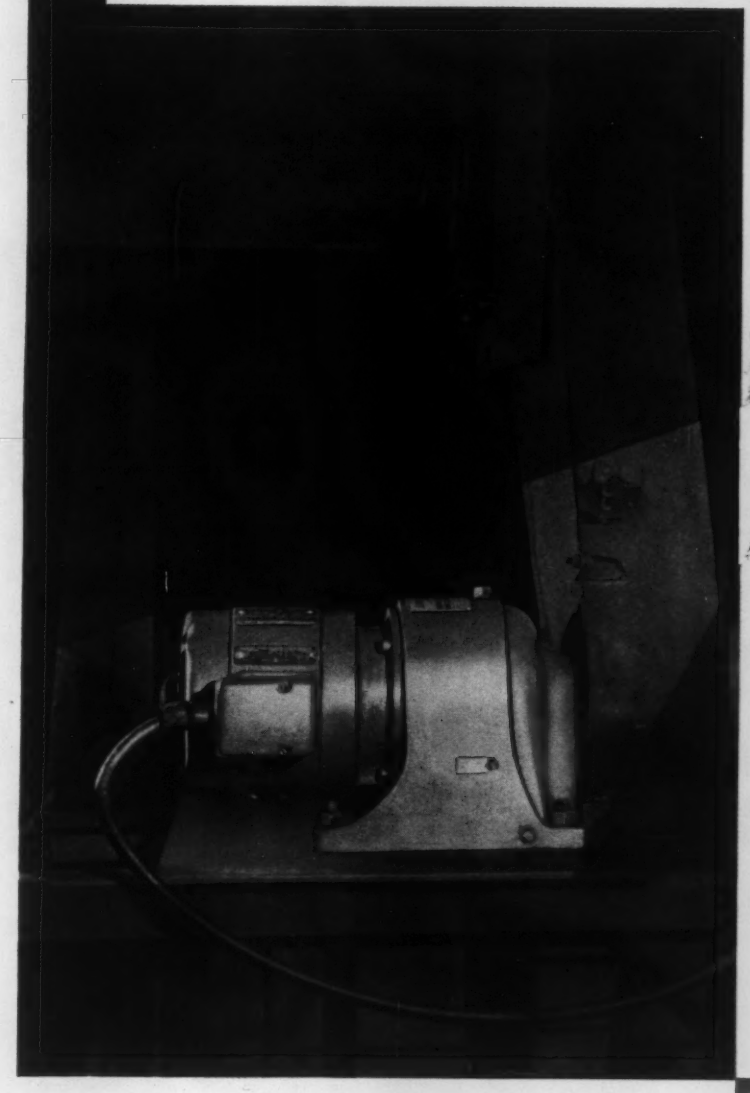
ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Tight space? Perfect place for a Link-Belt Gearmotor



Maintains life-long alignment with flange-mounted NEMA motors

Here's a speed reducer right in step with industry's campaign for higher productivity in less space. Because its gear trains incorporate a minimum of parts . . . because its motor is directly connected to the gear drive with a flange—the Link-Belt Gearmotor is the ultimate in compactness.

Imagine how these same features cut costs. The flange connection eliminates additional coupling devices. Simple gear trains have fewer parts to wear, to service, to invite trouble.

You'll find them in Book 2447. Call your nearby Link-Belt office.

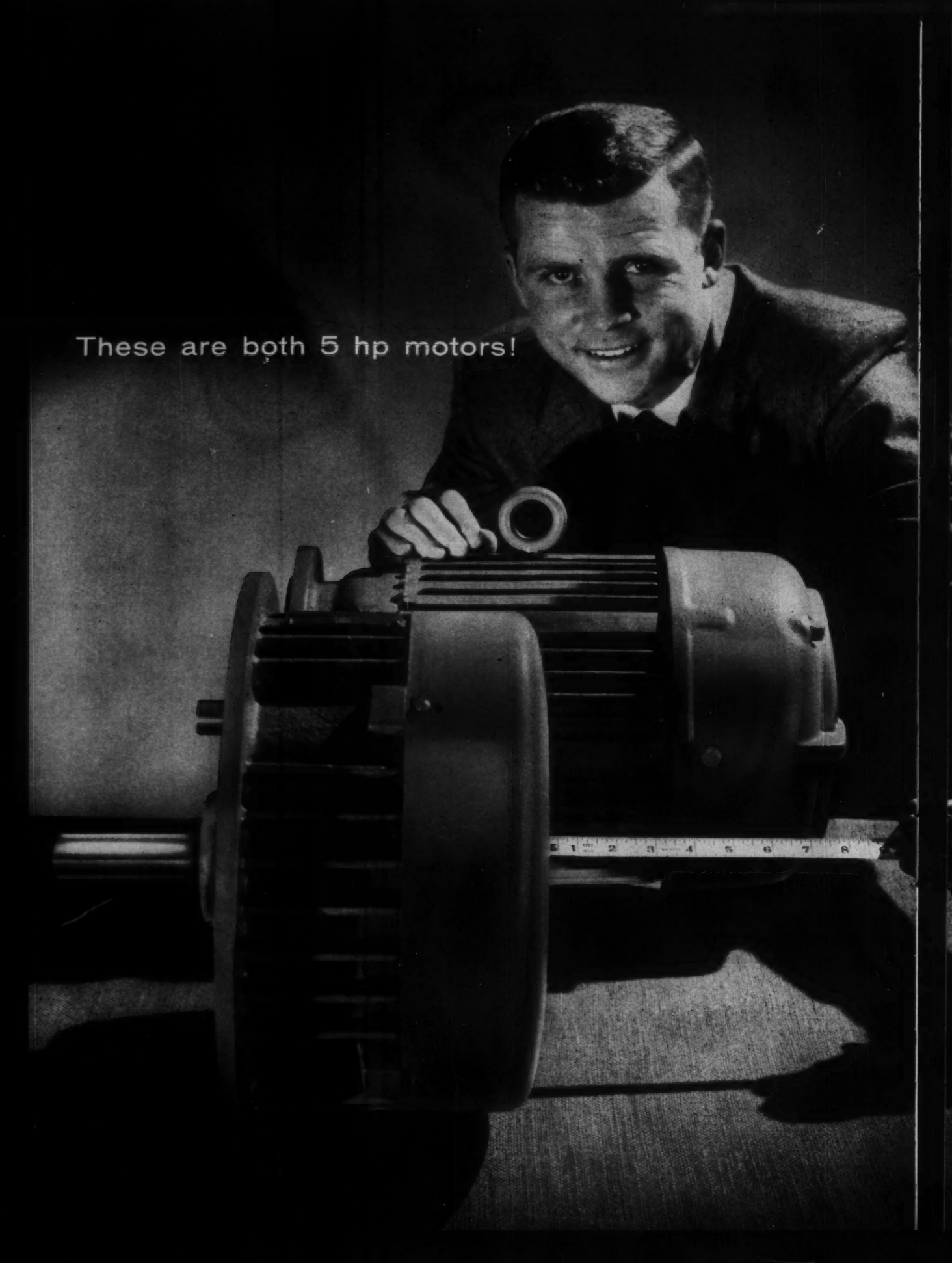
LINK-BELT MOTOGEAR—for bracket-mounting all makes and enclosures of foot-type NEMA motors — simplifies motor replacement. Sizes to 100 hp.

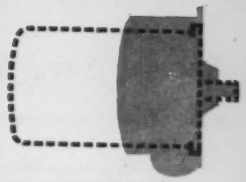
LINK-BELT

SPEED REDUCERS

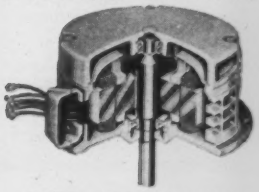
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,806-A

Circle 464 on Page 19


These are both 5 hp motors!



SAME NEMA RATING IN
60% LESS SPACE



PERFORMANCE-PROVED RADIAL
AIR-GAP DEPENDABILITY

New-product news from Louis Allis

60% shorter–
but with radial air-gap design!

New Louis Allis Pancake Motor preserves all the advantages of conventional motor construction

The new Louis Allis Pancake Motor is your solution to trouble-free power in any space-cramped motor application.

The Pancake is a remarkably short flange-mounted motor — up to 60% shorter and 33% lighter than standard motors of the same rating! And it is built in *conventional* radial air-gap design!

It's done by an ingenious forming process which literally compresses the end coils of a conventional radial air-gap motor into an exceptionally short length. The result is a compact, light motor ideally suited for horizontal or vertical mounting on machine tools, roof ventilating fans, or *any* close-quarter installation where space is a critical design factor.

What's more, this is achieved without sacrificing a single desirable characteristic: the stator still contains the same iron and copper as standard Louis Allis motors . . . standard NEMA service factor is maintained . . . high insulative values are retained by using proved Louis Allis varnishes and new insulating techniques . . . over-sized pre-lubricated bearings are used to guarantee long bearing life . . . and the entire motor is enclosed in an industrial-type cast-iron housing designed to shrug off abuse!

The housing and flange are cast in one piece: this permits extra-accurate internal machining which extends bearing life and reduces noise levels to a new low.

Investigate the Pancake Motor through your local Louis Allis District office. Sized from 1 to 15 hp, at 1800, 1200, and 900 rpm, in open drip-proof and enclosed non-ventilated or fan-cooled enclosures. Write for Bulletins 2100 and 2150 to the Louis Allis Co., 459 E. Stewart St., Milwaukee 1, Wisconsin.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

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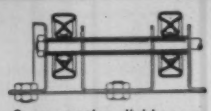
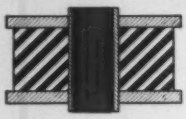
F-M Spacers Save Money in Hundreds of Applications. Spacers shown in Red

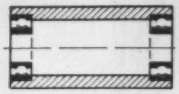


Cross member dividers on conveyor sections.

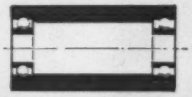


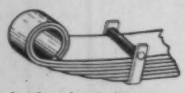
Motor mount bolt sleeve spacer.

Control rod spacers.



Before and after: Two spacers replace undercut machined wheel hub





Leaf spring bolt spacer.

Spacer-stabilizer linkage.

SAVE

Time, Money, Materials with Rolled, Split SPACER TUBES

Spacers can effect savings in many manufacturing and assembly operations—from automobiles to pull toys, phonographs to corn pickers. Furnished to your exact dimensions, ready to assemble, they are an economical substitute for iron pipe, tubing or machined parts; eliminate costly cut-off and de-burring machine time; save on secondary operations such as slots, holes, notches and chamfers. In steel, aluminum and stainless. Plain or plated. Many lengths, diameters and wall thicknesses. Complete engineering service.

FREE design data book on standard and special spacer specifications. Address:

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Heat dissipation front and back

Adjustable stops

Wear-resistant contacts

Stable operation, hour after hour

FOUR REASONS WHY

G-E rheostats give top performance at low cost

General Electric plate rheostats offer many outstanding features to give you the best possible performance with minimum cost and maintenance. These features include:

Greater heat dissipation—completely metal-encased and cement-filled rheostat dissipates heat from both sides. This allows a smaller, lower-cost rheostat to be used for a given rating.

Easily adjustable stops—two movable stops can be set to predetermine the range of operation of the G-E rheostat.

Less contact wear—the movable contact rides on special wear-resistant segments, not on the resistance wire. This substantially increases the operating life of the rheostat.

Stable operation—once the rheostat is set on the desired rating, it will maintain that setting with negligible change in resistance, resulting in dependable "set-and-forget" operation.

Act now! You can get G-E rheostats in six-, nine- or twelve-inch sizes, dissipating as high as 1100 watts per plate.

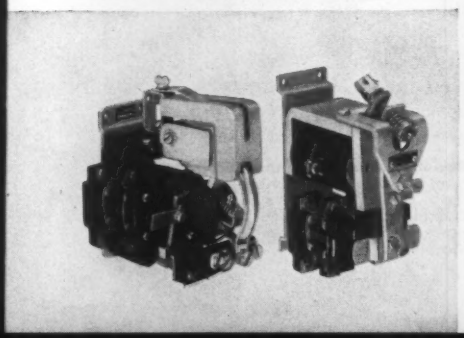
NEED OTHER COMPONENTS?

General Electric also has complete lines of contactors, relays and resistors for all your control needs. For more information, contact your G-E Sales Engineer or mail this coupon today! Industry Control Dept., Roanoke, Va.

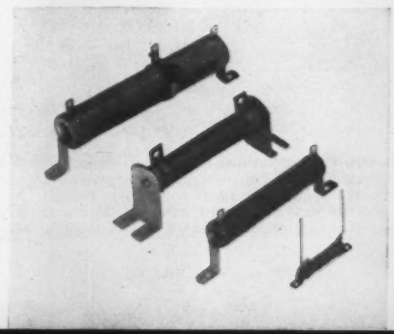
GENERAL ELECTRIC

Circle 467 on Page 19

D-c contactors and relays—feature new "building-block" construction to give maximum flexibility with minimum inventory.



Vitreous-enameled resistors—1070 ohmic values from stock, fixed or slide wire, 5 to 200 watts. Call your G-E representative.



To: Section C784-14
General Electric Co.
Schenectady 5, N. Y.

Please send the following bulletins:

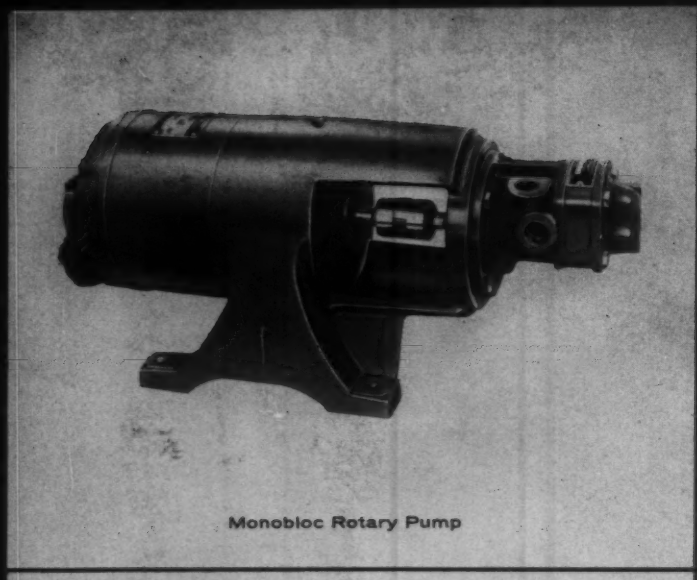
- ☐ GEA-6474—Plate-type rheostats
- ☐ GEA-6592—Vitreous-enameled resistors
- ☐ GEA-6621—D-c contactors and relays

Name _____

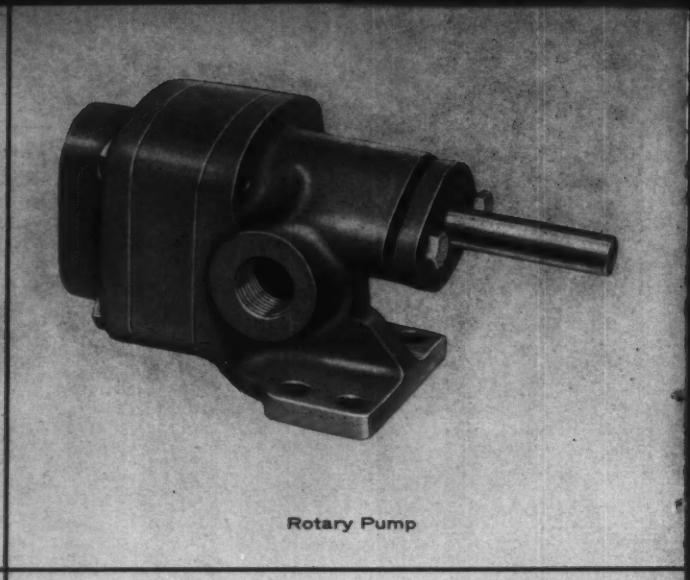
Company _____

Address _____

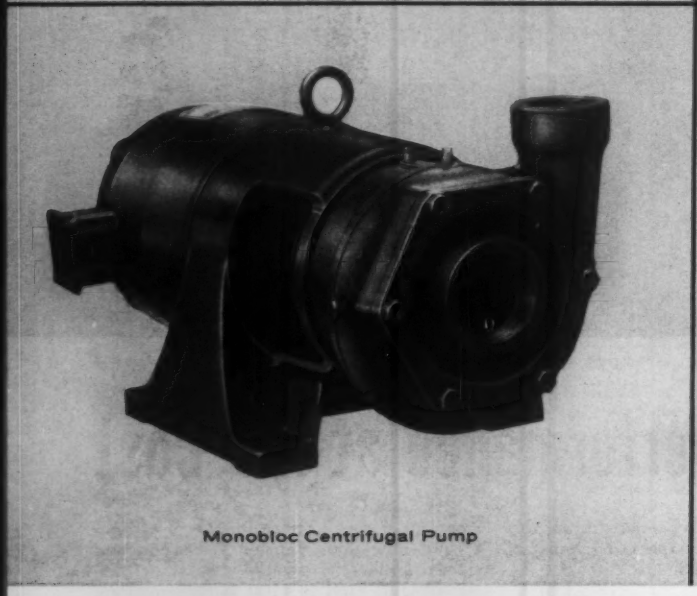
City _____ State _____



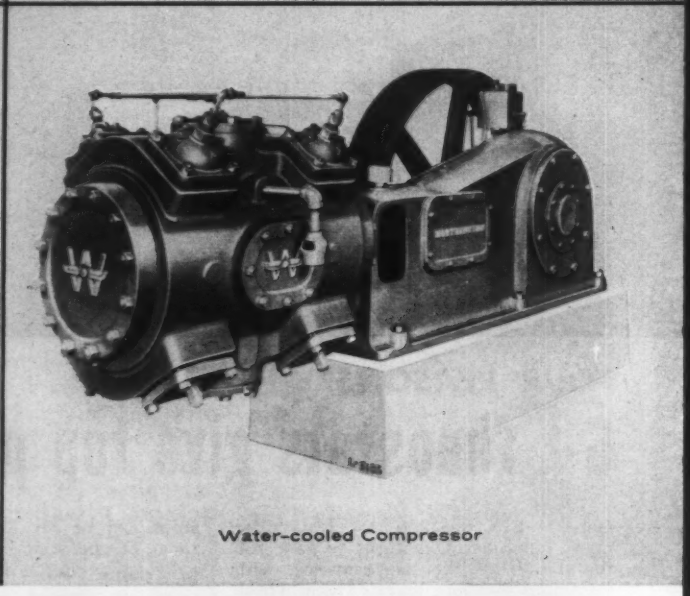
Monobloc Rotary Pump



Rotary Pump



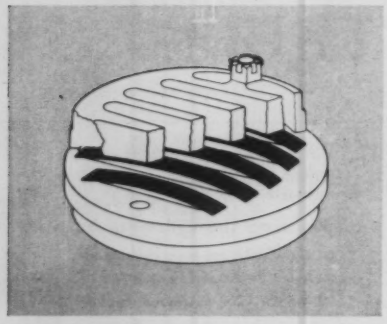
Monobloc Centrifugal Pump



Water-cooled Compressor

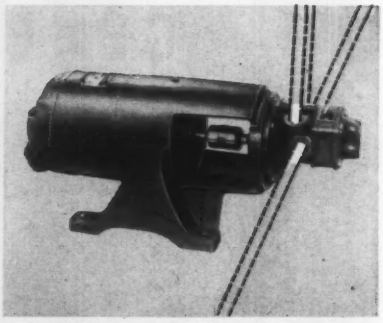
On any pump or compressor you choose, only Worthington gives you these

EXCLUSIVE

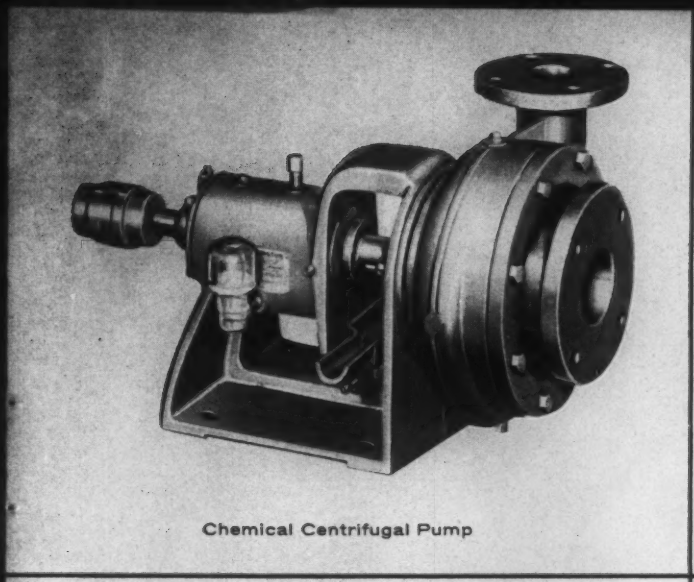


Feather Valve Lightest, fastest-acting compressor valve available. Works with no impact, is all but indestructible, and has an amazing record of long life with negligible maintenance costs.

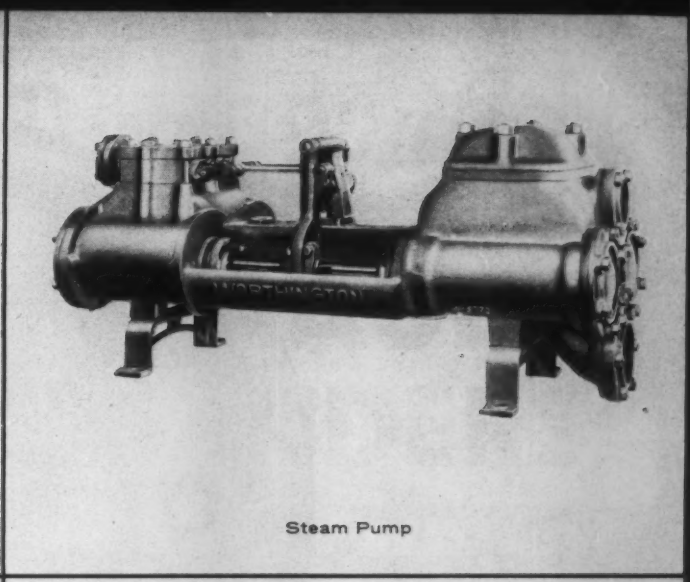
70,480 Combinations Completely standard and interchangeable components let you save up to 50% on spare parts inventory, permit you to design and build over 70 thousand "special" pumps using but 6 SESC pumps.



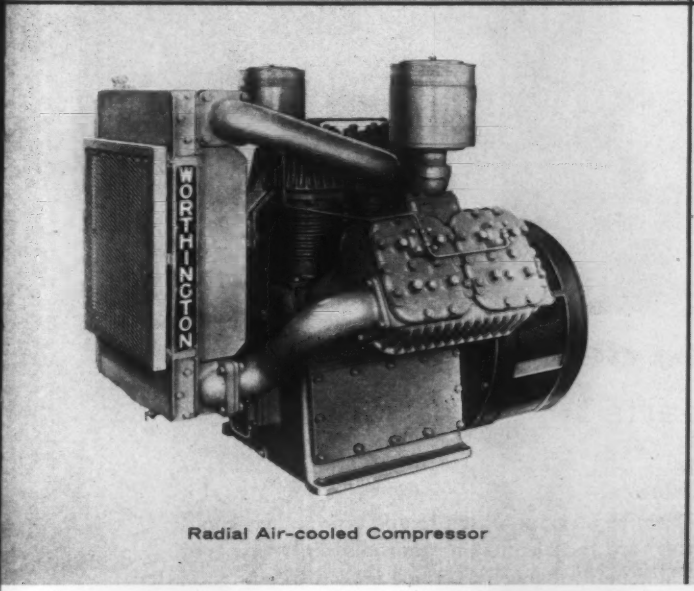
Monobloc Rotary Pump Eliminate alignment problems, simplify layouts by choosing up to 28 different ways to hook up pump piping. Saves you time, materials, is less expensive than separate pump, motor and baseplate.



Chemical Centrifugal Pump



Steam Pump



Radial Air-cooled Compressor

Balanced Angle Air-cooled Compressor

DESIGN ADVANTAGES

Designing and manufacturing outstanding products has been a success story typical of Worthington for 118 years. Foremost examples of this leadership and engineering skill are the exclusive design advantages of Worthington pumps and compressors. Three of the most important are illustrated at left: Feather Valves*, Monobloc Rotary pumps, and the unmatched flexibility achieved through standardization of the SESC (Standard End Suction Centrifugal) line.

Worthite*, Worthington's *super* stainless steel, has set new corrosion resistance standards for chemical pumps. Worthington air-cooled or water-cooled compressors include carefully balanced operating parts, low piston speeds, and liberal cooling surfaces on cylinders and intercoolers or aftercoolers. Increased performance and accessibility of portable and balanced angle compressors and the money-saving benefits of easy installation and low maintenance of the entire pump and compressor line lend further testimony to Worthington engineering competence. But whatever your application, your design problem, Worthington can help you.

Your nearby Worthington representative stands ready to explain the many advantages of one *complete* Worthington pump and compressor line to you. For more information on how to improve your product's performance or reduce engineering design and expense, contact him now. Or write for bulletin, Worthington Corporation, Section 104-7, Harrison, N.J. In Canada, Worthington, Ltd., Brantford, Ontario.

WORTHINGTON

*A high-nickel, high-chromium, low-carbon alloy steel. Trademark Reg. U.S. Pat. Off.

Circle 468 on Page 19

MEL-TROL® gives you **design insurance**

on forged high temperature parts

This turbine wheel forging will be machined down to 1/16 in. thickness in some sections.

The better the forgeability, the easier and less costly the machining. But there can be no sacrifice of high temperature properties when you are depending on the strength of a minimum cross section, as this design does.

The only way to get both forgeability and uniform high temperature performance is to make sure of the uniformity and quality of the steel itself. To get a uniform forging, you have to start with a uniform billet. And a uniform billet can only come from a uniform ingot.

That's what MEL-TROL gives you.

Users of MEL-TROL high temperature alloys report they are the cleanest forging alloys of their type. Their performance in service is consistently good. It minimizes the variations in service life found in conventional alloys.

It's the result of the finest quality control tools and procedures known today used together with a new, *Carpenter*-patented mold which produces ingots with the highest uniformity yet achieved in commercial steelmaking.

And it's easy to get this new kind of "design insurance." Just call the nearest *Carpenter* Service-Center. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter STEEL

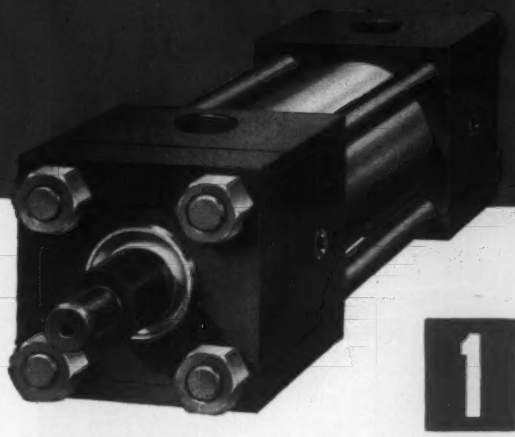
The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.
Webb Wire Division, New Brunswick, N. J.

SEAL FAILURE MEANS CYLINDER FAILURE

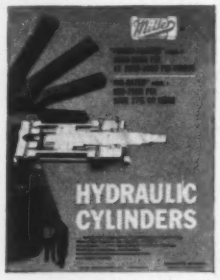
Petroleum base, fire-resistant and special hydraulic fluids cause distortion and rapid deterioration of the seals currently used in many hydraulic cylinders, resulting in costly repairs and cylinder failure. (Seals made of synthetic rubber are not compatible with even 50% of available commercial petroleum base fluids and the life of such seals is materially reduced at operating temperatures above 150° F.)

Specify Miller HYDRAULIC CYLINDERS

FOR UNLIMITED SEAL LIFE!



Request Bulletin JH-104N for complete data plus helpful charts on column strength, cylinder forces, factors of safety, acceleration, pipe pressure losses, etc.



1 ALL TEFLON* SEALED Against External Leakage

TEFLON is impervious to all known hydraulic fluids, including all fire-resistant and special types—and withstands temperatures from —100°F. to plus 450°F.

TEFLON SHEF SEAL AT TUBING ENDS

No blind assembly. Is
Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

TEFLON SEALS ON PISTON ROD AND BUSHING

Teflon rod flange seal requires no adjustment. Teflon bushing seal is shearproof. Teflon wiper keeps dirt out.

TEFLON SEALS ON BALL CHECK AND ADJUSTING SCREW

Non-protruding, self-locking, cushion adjusting screw interchangeable with ball check for easy access.

2 CASE-HARDENED CHROME PLATED PISTON RODS

Provide foolproof protection against seal failures resulting from rod damage. The Miller case-hardened rods (50-54 Rockwell C) give practically complete immunity to damage from hammer blows, wrench-dropping, mishandling, etc. The hard chrome plating over the case-hardened rods protects against scratch-damage and rust.

AVAILABLE IN TWO TOP QUALITY LINES

JOB-RATED
Model "J"

PRICE SAVINGS OF 27% OR MORE!

19 mounting styles, all strokes, cushioned and non-cushioned. Large selection for immediate shipment.

BORE	SEVERE OPERATING CONDITIONS	MODERATE OPERATING CONDITIONS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*

POWER-PACKED
Model "H"

50% More Power Per Cylinder Dollar!

For

3,000-5,000 P.S.I.

1½" through 12" bores, 17 mounting styles, strokes up to 22 ft., cushioned and non-cushioned. Large selection for immediate delivery.

*DuPont trademark for its tetrafluoroethyline resin

S SHEAR PROOF
H HEAT PROOF
E EXTRUSION PROOF
F FLUID PROOF
SEAL
Teflon Pressure Energized
Hydraulic Cylinder Tubing End Seal
PAT. APPLIED FOR

OTHER MILLER QUALITY FEATURES

- Solid Steel Heads, Caps and Mountings.
- Precision-Honed Barrels.
- Rust-Resistant Coating on All Non-Wearing Surfaces.
- Space-Saving "Square" Design.

MILLER FLUID POWER
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AIR AND HYDRAULIC CYLINDERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS • BOOSTERS
Circle 470 on Page 19

Memo on Metals

New Study Shows Crucible 56 Offers the Stability, Tensile and Yield Strengths Needed in 800—1000° F. Applications

A recent study considers three steels which show promise of solving the high temperature strength problems encountered in today's high speed flight.† These problems of maintaining structural strength at elevated temperatures are further complicated by the need for favorable strength/weight ratios.

Two of the steels are hot work types (Crucible 218 and 56) that are only now being considered for structural applications in aircraft. Crucible 56 is a relatively new steel, offering an unusually high level of stability at high temperatures. The chemistries of the three steels are as follows:

CHEMICAL COMPOSITION

Grade	C	CR	Ni	Mn	Mo	V	Si	Al
Crucible 56	.40	3.30		.60	2.75	.40	1.00	
Crucible 218	.38	5.20		.35	1.40	.50	1.10	
AISI 4340	.40	.80	1.80	.70	.25		.30	

Figs. A and B compare the tensile and yield strengths of the three steels at the exposure temperature. The curves show that both Crucible 56 and Crucible 218 proved superior in these tests. However, the hardness-tempering curve for Crucible 56 shows that it is more stable than the other analyses evaluated. Crucible 56 also offers higher hardness (and hence, strength) when tempered in the 1050-1100° F. range. As the comparisons indicate, it also has higher elevated temperature tensile and creep properties than Crucible 218, which is a conventional AISI type. In Fig. C, the isochronous (constant time) stress-strain curves illustrate the stability of Crucible 56 at the top of the service temperature range. With these curves it is possible to determine the stress at which creep becomes an important consideration.

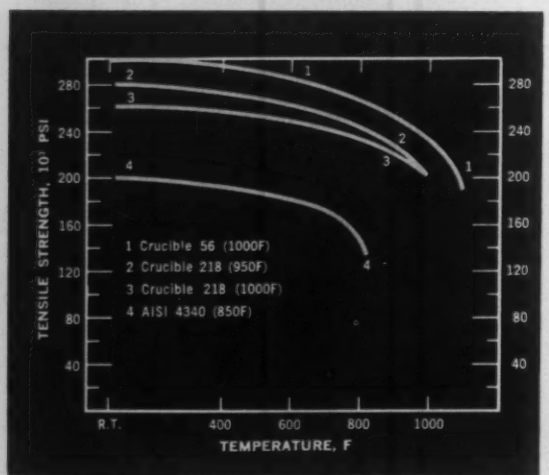


Fig. A. Tensile strength of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

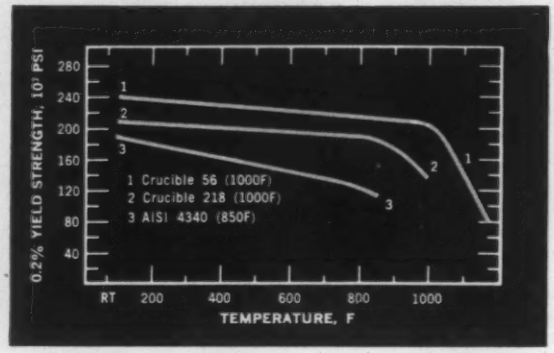


Fig. B. Yield strength (0.2% off-set) of various steels at exposure temperatures. Figures in parentheses are tempering temperatures.

For further details on Crucible 56 and other comparative data, send the coupon.

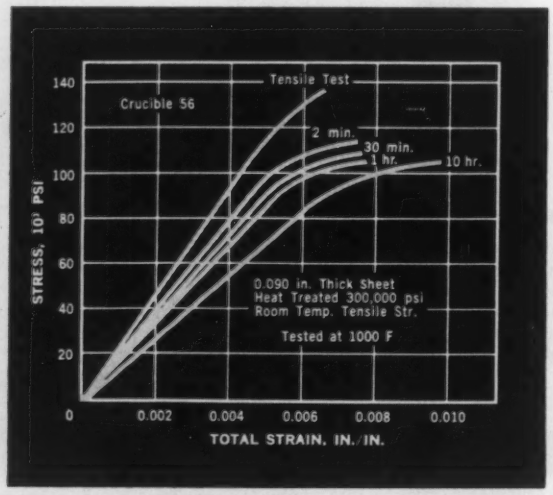


Fig. C. Isochronous stress-strain curves for Crucible 56 sheet show the outstanding creep properties of this steel which are higher than any other steel at 1000° F.

†Although this study considers only aircraft applications, data given here may prove helpful in designing turbines, chemical processing and nuclear equipment, and other equipment where service temperatures ranging from 800-1000° F. are required.

* high temperature strength
* vacuum melting
* cast properties of UHS-260

Compares properties of bearing steels produced by various melting techniques

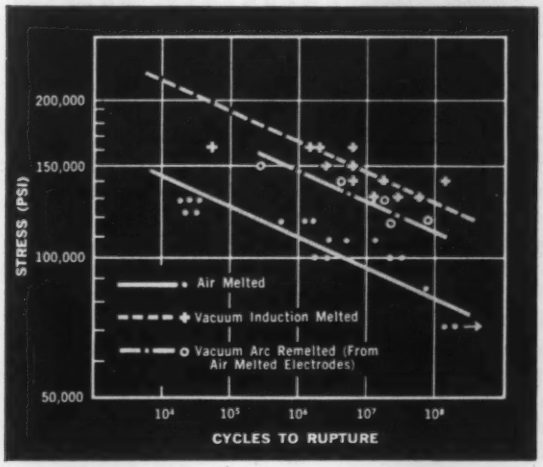
High vacuum technology has expanded considerably in recent years. The degree of improvement obtainable can be shown by comparing the properties of SAE 52100 produced by various melting techniques.

The following table gives gas content analyses of this chromium-carbon steel when produced by air melting (AM), air melting and vacuum arc remelting (AM+VAR), vacuum induction melting (VIM) and double melting (VIM+VAR):

Melting Technique	O(PPM)	N(PPM)	H(PPM)
AM	30	100	< 1
AM+VAR	7	70	< 1
VIM	5	3	< 1
VIM+VAR	3	3	< 1

Reduction in gas content is important, of course, because gases have varied detrimental effects on alloys. Oxygen increases transition temperature and forms various types of inclusions. Nitrogen effects aging, fatigue and stress rupture.

Similar improvement is obtained in cleanliness. (Inclusions strongly influence properties such as fatigue, impact and ductility.) Vacuum induction melted 52100 shows very small sulphide and oxide inclusions. Its background is extremely clean. Vacuum arc remelted 52100, made from air melted electrodes, also shows significant improvement over the air melted steel. Still further improvement is available with double melting.



Up to now, vacuum melted 52100 has been used mainly in bearings for jet engines, grinder spindles and instruments. It is credited with extending "B-10" life (the life at which 10% of the bearings fail) from 65 hours to 375 hours. Premature failures have been virtually eliminated. And the average number of production rejects of finished balls has dropped from 15% to 0.3%—savings that in some cases pay for the slightly higher cost of the vacuum melted alloy.

For more data on vacuum melted SAE 52100—or data on other vacuum melted ferrous and non-ferrous metals and alloys—send the coupon.

UHS-260 in cast form offers high strength with good ductility

New studies of the cast properties of UHS-260 should prove interesting to designers of structural parts for aircraft. In cast form at high temperatures, UHS-260 offers very high tensile strength with ductility equal to or better than transverse properties of the wrought form. Data from a preliminary report is given below. *For more complete information send the coupon.*

Grade UHS-260 Cast Properties —Preliminary Report

Nominal Composition

C	Si	Mn	Mo	Cu	Fe	Cr	Ni	V	Condition
0.35	1.50	1.35	0.30	—	Bal.	1.25	—	0.30	Hardened & Tempered

Mechanical Properties

	Test Temp °F.	Tensile Strength psi	Yield Strength psi	% Elong	% R.A.	Charpy Impact
Mean	−40°	265,000	218,000	6	10.5	7
High		268,000	226,000	6.5	15	8
Low		262,000	213,000	4	9	6
Mean	76°	260,000	217,000	4.5	12.5	7.7
High		265,000	241,000	6	16	8
Low		257,000	211,000	4	7	6
Mean	400°	266,000	191,000	5	7.3	11
High		269,000	205,000	6	10	13
Low		261,000	183,000	4	5	9
Mean	600°	237,000	162,000	9	18	11.3
High		240,000	172,000	10	23	12
Low		234,000	153,000	8	13	10
Mean	800°	200,000	147,000	9.6	29	12.3
High		232,000	179,000	13	42	13
Low		189,000	131,000	3	4	12

CRUCIBLE STEEL COMPANY OF AMERICA
Dept. EK07, The Oliver Building
Mellon Square, Pittsburgh 22, Pa.

Gentlemen:

Please send me the following:

1. Crucible 56 Data Sheet_____ Comparative Data_____
2. Data sheet on vacuum induction melted SAE 52100_____
3. Data on other VIM metals_____
4. Further information on the cast properties of UHS-260_____

Name_____

Title_____

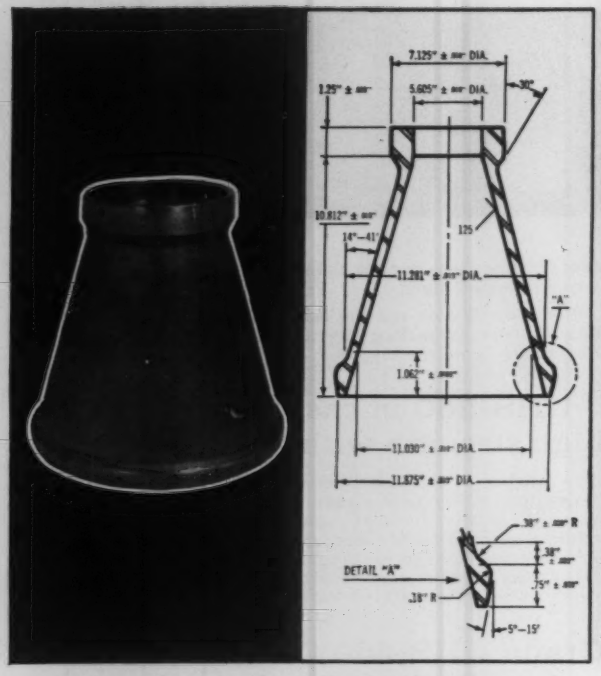
Company_____

Street_____

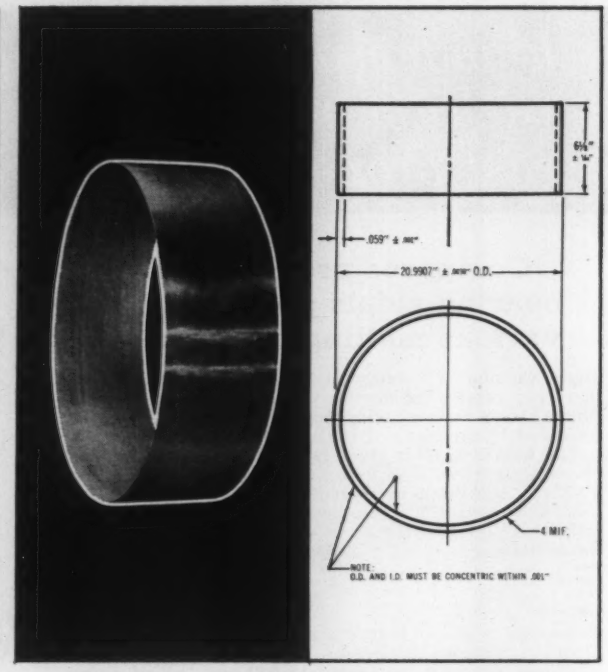
City_____ Zone_____ State_____

CRUCIBLE STEEL COMPANY OF AMERICA

Circle 471 on Page 19



STRAIGHT SIDE ROCKET CONE—Spun with tapered wall from 1020 steel blank: 18" diameter, 1" thick. Inside surface 125 MIF.



STRAIGHT WALL TUBE PRINTING BAND—Spun from ⅛" thick aluminum to .060" wall thickness, outside surface machine finished to 4MIF.

ROTOFORMS open new

ROTOFORMING reduces cost of unusual metal shapes—saves metal, eliminates machining and surface finishing

The design possibilities for hollow metal shapes are now unlimited. The most unusual metal custom parts can be practically and economically produced by ROTOFORMING.

This revolutionary new metal forming service now being offered by COMMERCIAL SHEARING & STAMPING displaces metal in a blank or preform. Rollers contacting the outside surface of the metal form it by high pressure as it rotates around a mandrel. The shape of the mandrel itself, at all times, controls the inside contour and size of the part.

WHAT SHAPES ARE POSSIBLE? Basically, ROTOFORMS can be grouped into four main categories: Straight-Side Cones, Straight-Wall Tubes, Curvilinear-Wall Shapes, and Elliptical or Hemispherical Shapes. Pictured above are representative ROTOFORMS already produced by COMMERCIAL. Principal dimensions are included.

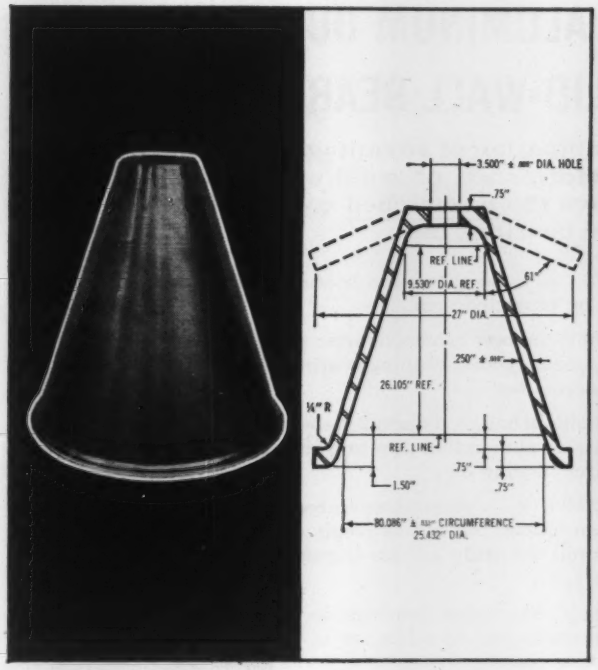
WHAT ABOUT SIZE AND WALL THICKNESS? The range of sizes for ROTOFORMS covers maximum diameters up to 42" down to a minimum tube I.D. of 2¼". Tube length can go as high as 100".

Steel blanks up to ¾" thick can be successfully handled by ROTOFORMING where conical shapes are involved. And when it comes to forming straight-wall tubes the wall thickness of steel blanks can even go up to ⅝". When forming metals more ductile than steel it is possible to work blanks with even greater wall thicknesses than those above.

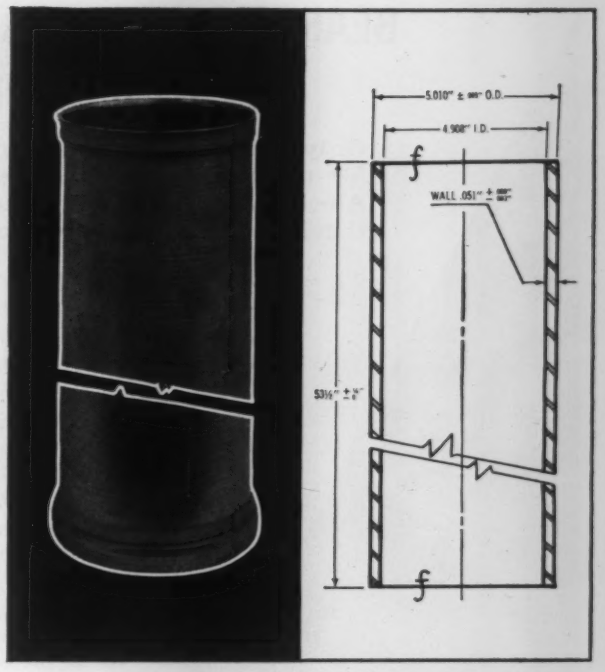
With ROTOFORMS wall thicknesses—both constant and variable—are feasible. Walls referenced to C/L can be straight, curved, or tapered. And ROTOFORMS have been successfully produced with a finished wall thickness no greater than $\frac{1}{32}$".

WHAT METALS CAN BE ROTOFORMED? A wide variety of carbon steels, stainless and special alloy steels, as well as aluminum, nickel, copper, molybdenum, magnesium and titanium alloys can be successfully ROTOFORMED. Even metal alloys such as 4130 steel, 1100-0 aluminum, and hard to machine Hastelloy, can and are being used in the regular production of ROTOFORMS.

WHAT HAPPENS TO THE METAL? The plastic deformation which metals undergo in the ROTOFORMING process elongates their grain structure and sub-



STRAIGHT SIDE MISSILE EXIT CONE—Spun with constant wall thickness from press pre-formed 1040 steel blank: 29" diameter, ¾" thick.



STRAIGHT WALL ROCKET TUBE—Spun from 4135 steel tubing (wall thickness ½") reduced to finished wall .051".

horizons for metal shape design!

stantially increases their strength. Tensile increases 1½ to 2 times, yield point is raised in even higher proportion, and fatigue strength is substantially improved. And ROTOFORMED parts can be heat treated to increase their ductility.

Because of the plastic deformation of metal, involved weld joints become unnoticeable when ROTOFORMED. And there are no hidden metal flaws in ROTOFORMS. Any metal inclusions or flaws in the parent metal are quickly uncovered during the ROTOFORMING process—appear as ruptures when pressure spinning rolls reposition the metal by physical displacement. Only 100% sound metal will produce successful ROTOFORMS.

WHAT ABOUT TOLERANCES AND FINISHES? Extremely close tolerances and tolerances commonly associated with fine machining are routine in the production of ROTOFORMS. It is not uncommon for ROTOFORMED parts taken from the machine as is to have inside diameters held to tolerances of +.000" −.003", +.005" −.000", and +.005" −.005".

Inside areas of ROTOFORMS finish to a glass-like surface—30 to 60 micro inch finishes being well within standard production practice. While outside surfaces finish to about 125 micro inch.

Because dimensional tolerances and inside surface finish have a direct relation to the variation and finish of blank from which the ROTOFORM is produced, when necessary the tolerances of a blank can be reduced and its finish improved beforehand in order to provide closer tolerances and a better inside finish in the actual ROTOFORM. In addition, the outside surfaces of ROTOFORMS can be brought to smoother finish by grinding, polishing or fine machining.

AN INVITATION FROM COMMERCIAL! This new metal forming process could be the practical and economical answer to your particular component problem. You can find out very quickly. Just a blueprint, sketch or prototype of your part in the hands of our engineers will bring you the complete cost-saving story—and at no obligation. Address inquiries to Commercial Shearing & Stamping Co., Dept. S-46, Youngstown 1, Ohio.

COMMERCIAL
shearing & stamping

Circle 473 on Page 19

BEARINGS OF ALCOA ALUMINUM OUTPERFORM ALL OTHER SOLID-WALL BEARINGS...

Only aluminum has the combination of advantages demanded for the best all-around performance of solid-wall bearings. Alcoa® Aluminum alloys have the unmatched combination of these advantages to give you bearings that:

Withstand heaviest loads . . . Solid aluminum bearings withstand loads up to 10,000 psi on projected area.

Run cooler . . . Aluminum is the best heat conductor among bearing materials, and this means cooler running bearings . . . as much as 20° cooler by actual test.

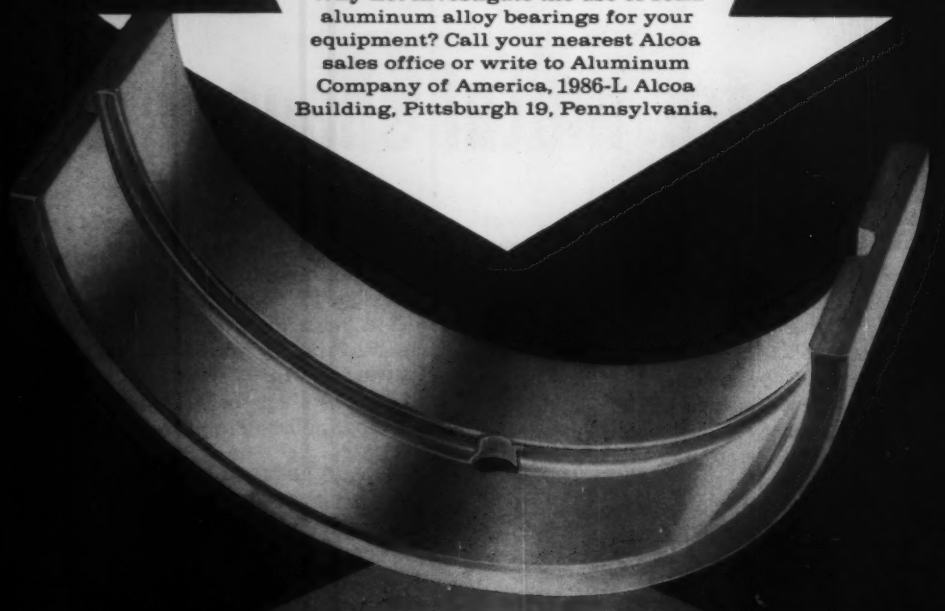
Conform readily . . . Aluminum has good ductility, conforms readily to misaligned shafts or nonparallel pins and thus reduces unit loading for longer bearing life.

Have ideal embeddability . . . Aluminum embeds particles far better than bronze, but not as deeply as babbitt. Dirt particles roll out easily and are trapped by the filter.

Resist corrosion . . . Aluminum bearings do not corrode . . . are unaffected by additives in oils, need no protective coating.

Have design flexibility . . . The structural properties of aluminum give great design flexibility, ease of machinability.

Why not investigate the use of solid aluminum alloy bearings for your equipment? Call your nearest Alcoa sales office or write to Aluminum Company of America, 1986-L Alcoa Building, Pittsburgh 19, Pennsylvania.



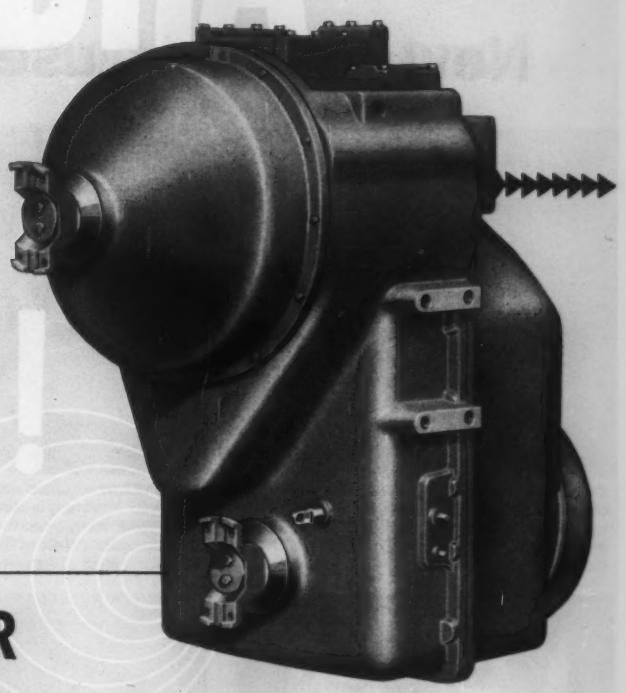
ALCOA ALUMINUM BEARINGS

. . . Your Guide to the Best in Aluminum Value

"ALCOA THEATRE"
Exciting Adventure.
Alternate Monday Evenings

new addition to

HYDRA-DRIVES® LINE!



FULL-POWER SHIFT TRANSMISSIONS now available for equipment of from 60 to 175 h.p.

Rockwell-Standard's new model Hydra-Drives *Full* Power Shift Transmission is now available in sizes especially designed for smaller installations, such as front end loaders, fork trucks, scrapers, crane carriers, rubber tire tractors and military vehicles. A single compact package combining torque converter and 4-speed, *all power shift* transmission, the Type BDB Transmission puts power to work smoothly, efficiently and economically.

Only the Hydra-Drives BDB offers all these major advantages:

4 Speeds Forward and Reverse. All Power Shifted! Provides for maximum horse power to load under all load conditions.

Easier Servicing and Maintenance. Fewer moving parts and bearings. Simple, rugged countershaft design and spur gears simplify maintenance.

Full Disconnect provides for split drives and makes it easier and safer to tow.

Dual Reduced Speed Pump Drives can be driven at engine speed or 4/5 engine speed for longer pump life and increased horse power to load.

Integral Design. Torque converter, transmission, oil passages, valving and oil sump are in one compact housing. Package is less bulky... up to 7¾ inches shorter than comparable models. Provides easier installation and less maintenance.

HYDRA DRIVES

ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

©1958, R-S Corp.

Circle 475 on Page 19

DU PONT

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

PRODUCT

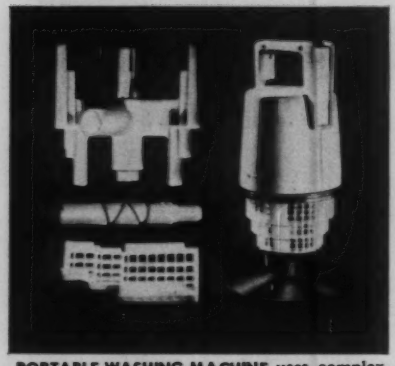
ZYTEL®

New products use ZYTEL® nylon resin

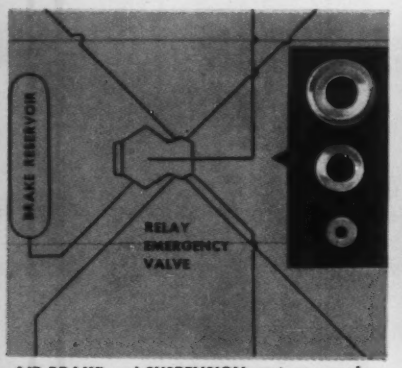
CHECK VALVE won award for best use of materials in design. Parts were reduced from 10 to 6 and their cost cut by 68%. (Molded by Hamilton Plastic Molding Company for OPW Corp.—both of Cincinnati, Ohio.)

GEAR TRAIN of office duplicator, shown with side cases removed, is made of Du Pont ZYTEL nylon resin. Parts operate quietly . . . are strong and durable. (Molded by Hauser Products, Inc., for Heyer Corp.—both of Chicago, Ill.)

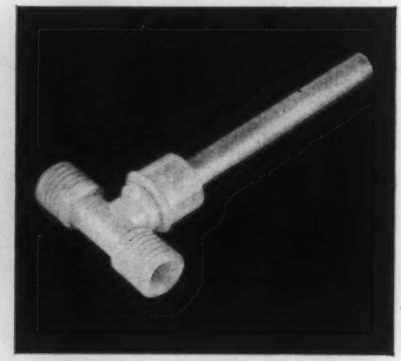
COUPLING employs ring gear of Du Pont ZYTEL nylon resin. High strength, no lubrication are featured. 162M coupling is rated at 3½ HP per 100 rpm. (Made by John Waldron Corporation, New Brunswick, New Jersey.)



PORTABLE WASHING MACHINE uses complex moldings of ZYTEL for light weight . . . chemical and corrosion resistance. (By Michigan Plastics Products, Grand Haven, Michigan for AMI, Incorporated, Grand Rapids, Michigan.)

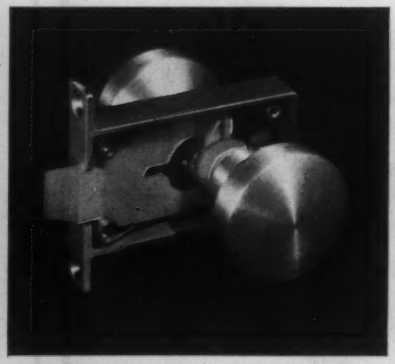


AIR BRAKE and SUSPENSION systems employ rugged parts of Du Pont ZYTEL. Safety, cost savings, sealing ability, close tolerances, determined choice. (Systems by Bendix-Westinghouse, Elyria, Ohio.)

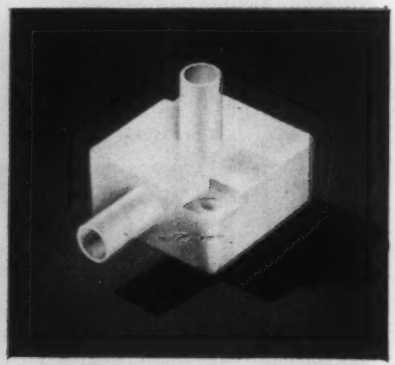


TUBE FITTING simplifies installation . . . assures leak-proof seal just by hand tightening. Molded of ZYTEL, it eliminates tools, solvents . . . does not restrict tubing I. D. (By Danielson Manufacturing Company, Danielson, Connecticut.)

SPRAY NOZZLE of ZYTEL withstood all farm chemicals in two years of field testing. Hard surface of nozzle resists erosion. (By Century Engineering Corporation, Farm Equipment Division, Cedar Rapids, Iowa.)



AIRCRAFT DOOR LATCH of Du Pont ZYTEL nylon resin resists abrasion, prevents door rattle, needs no lubrication. (Molded by TEKSUN, Inc., Los Angeles, California, for Adams-Rite Manufacturing Company, Glendale, Calif.)

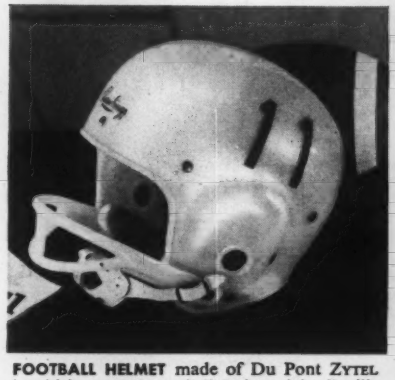


VALVE BODY is solenoid-actuated. Handling acid, citrus juices . . . ZYTEL outlasts materials previously used. (By Nylon Molding Corporation, Garwood, New Jersey, for Valcor Engineering Corporation, Kenilworth, New Jersey.)

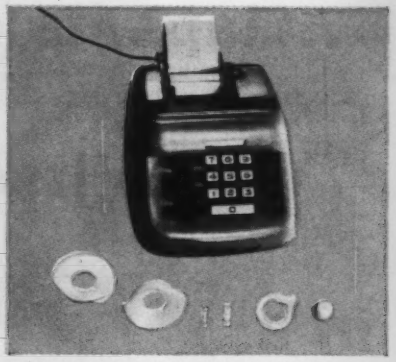
ENGINEERING NEWS

NYLON RESINS

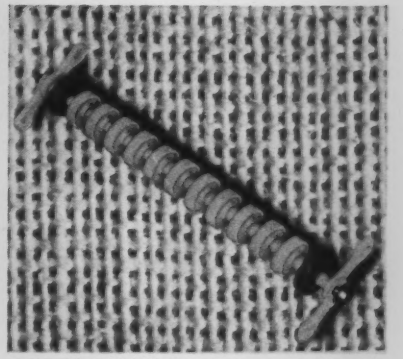
for improved design and performance...



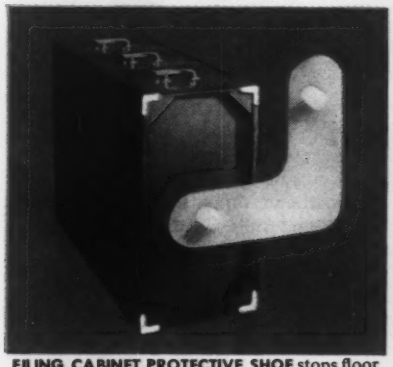
FOOTBALL HELMET made of Du Pont ZYTEL has high strength . . . is light in weight. Resilience of ZYTEL helps take the shock out of roughest scrimmage. (By Rawlings Sporting Goods Co., St. Louis, Missouri.)



ADDING MACHINE uses cams and other components of ZYTEL for smooth, quiet operation. Elimination of waste and machining steps produces cost savings. (Manufactured by Underwood Corporation, Hartford, Connecticut.)



PATTERN CHAIN for loom outwears steel, needs no oiling, does not soil product. Light weight saves power. (Parts molded by Bolta Products, Lawrence, Massachusetts, for H. F. Livermore Corporation, Boston, Massachusetts.)



FILING CABINET PROTECTIVE SHOE stops floor staining by preventing contact of cleaning liquids with metal base. Slides more easily . . . no floor scratches. (Molded by Vaupell Industrial Plastics, Inc., for Vanguard Sales Co.—both of Seattle, Washington.)

CABLE CLAMPS secure wire, cable and conduit to structural framework of aircraft. Molded of lightweight, resilient ZYTEL, they form a perfect circle with tongue and groove giving a positive, vibration-proof grip. (Molded by Nylon Molding Corp., Garwood, New Jersey.)

And here's why ZYTEL® cuts production and design costs

In many cases ZYTEL will do the job of other materials at less cost with equal or better performance. This is partly due to the strength of ZYTEL—impact strength, load strength, abrasion resistance.

Just as important are the processing economies you can achieve with ZYTEL nylon resin. Highly complex parts can be molded at lower cost. When production runs are large, great savings are possible by the use of injection molding and multiple-cavity dies. Fast cycles are attained because of the rapid setup of the resin. Material waste is negligible. Finishing processes are often eliminated entirely, because ZYTEL can be molded to close tolerances with extremely smooth surfaces. Many designers have replaced costly assemblies of machined parts by a single molding of ZYTEL.

The advantages do not end here. ZYTEL is colorable, chemically resistant, heat-resistant. It has a low coefficient of friction, resilience, light weight. Numerous formulations of ZYTEL nylon resin permit even greater versatility... provide special processing and end-use advantages.

Find out how ZYTEL can improve your products and reduce costs by sending the coupon.

PLASTICS EXPOSITION
NOV. 17-21 · CHICAGO

Circle 476 on Page 19

E. I. du Pont de Nemours & Co. (Inc.)
Polychemicals Department, Room 2211, Du Pont Building
Wilmington 98, Delaware.

Please send me more information on Du Pont ZYTEL nylon resins. I am interested in evaluating this material for:

Name _____ *Position* _____

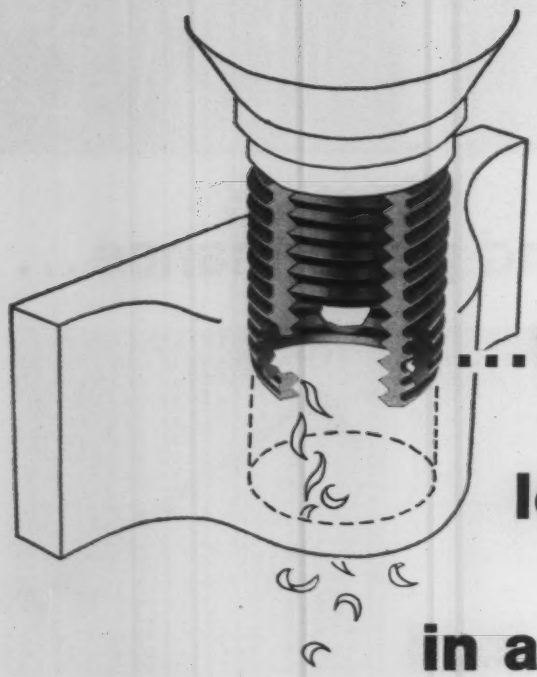
Company _____

Street _____

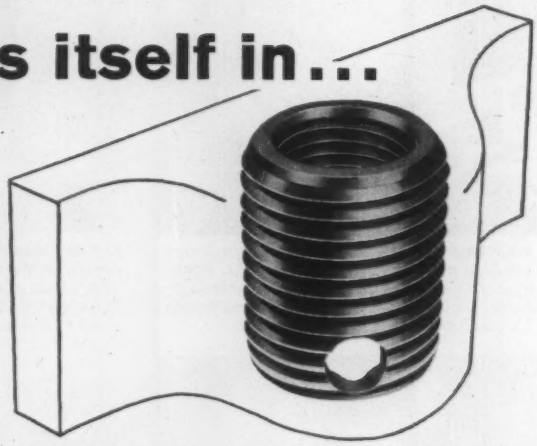
City _____ *State* _____

Type of Business _____

In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec



The TAP-LOK® threaded insert ...taps its own thread ... locks itself in ... in a single operation!



TAP-LOK inserts provide strong wear-resistant threads in relatively soft machinable materials (wood, plastic, aluminum, etc.) . . . as well as in *harder* materials where repeated assembly makes excessive thread wear a problem.

Unlike ordinary threaded inserts, however, TAP-LOK inserts cut their own threads in the parent material. Thus, *no additional assembly time is required* with a TAP-LOK insert.

Its installed cost is the lowest of any threaded insert.

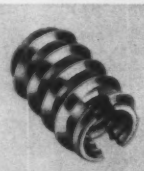
The locking action is achieved in this way: the tapered pilot section carrying the thread cutting edges is followed by the full diameter threads which force their way into the parent material. Once installed, a TAP-LOK insert is permanently locked in place.

Available in the types shown below, TAP-LOK inserts can be used wherever threaded inserts are required. Write today for complete information.

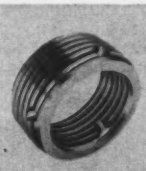
Slotted:—Full V-form external threads provide maximum locking torque; permit wide choice of mating hole sizes. Recommended for soft aluminum, zinc die castings, sand castings, plastics. Class 2B internal thread — MIL-MS 35914.

H-Series:— A heavy walled insert with truncated root external thread and three-hole cutting edges for hard-to-tap higher-strength materials and to meet MIL and other specs calling for Class 3B thread fit for gaging after installation.

N-Series:— Nylon locking pellet embedded in threads makes internal threads self-locking. Ideally suited for adjustment screws and applications involving severe shock and vibration. Meets requirements of MIL-N-25027 (ASG).



W-Series:—Coarse-pitch external thread offers maximum strength; permits installation in small wooden sections without splitting. For furniture, cabinets and other wooden parts where strong, permanent threads are required.



P-Series:—This Tap-Lok insert was designed to eliminate thread wear and renew damaged threads in spark plug sockets in aluminum cylinder heads. It is available from stock for standard plug sizes to meet most needs.

TAP-LOK

Another fastener development from—

GROOV-PIN CORPORATION

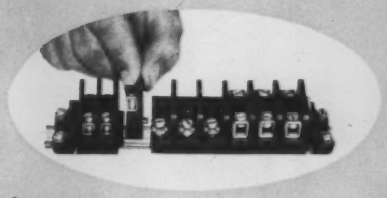
1130 Hendricks Causeway, Ridgefield, N. J.

Circle 477 on Page 19

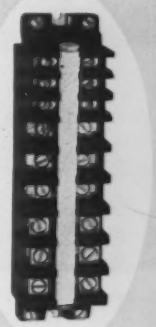
50% MORE TERMINALS IN THE SAME SPACE!

SQUARE D's *NEW* TERMINAL BLOCKS

MORE FLEXIBILITY, TOO!



NOTICE *(above)* how little space is required to remove or add a Square D channel-mounted terminal block to the completely assembled unit. Especially important for a quick change when an additional terminal must be inserted into grouping.



LOOK *(at right)*... all sizes can be mounted on same channel...25 ampere pressure wire connectors, 25 to 50 ampere box lugs ...all can be interlocked together. Terminals in kit form to "do-it-yourself" or factory-assembled to standard specifications.

SEE *(below)*...there is only one perforated channel required for either weld or screw-on mounting...available in standard lengths that can be cut "on the job" to fit any length requirement. Eliminates stocking various sizes.

ASK YOUR SQUARE D FIELD ENGINEER
or write for Bulletin which covers details on Channel-Mounted Terminal Blocks. Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.

NOW...EC&M **PRODUCTS ARE A PART OF THE SQUARE D LINE**

SQUARE D COMPANY

Reliability—Everyone has a different picture of reliability. To millions of us, it means an unthinking faith in the slender steel ropes that hoist an elevator car. To the captain of a ship, it's a staunch steel hull that will resist the wrack of any storm. To the policeman on the beat, it's the oil-smooth action of a steel revolver that must never fail.

So it is that whenever man decides to make something that is completely reliable, he usually makes it from steel. The reason is simple: steel is the strongest, toughest material on this planet that can be bought at a reasonable price.

More than that, it's so easy to *use*. With heat treatment, most steels can be made soft enough to work, then strong enough to carry the load, then tough enough to take the pounding of any application. With many steels, you can achieve 100% efficient welded joints. All this in a material that is universally available, in an infinity of grades, shapes, sizes, finishes and preforms.

Ironically, the great *variety* of steels often causes trouble for the designer. No matter what combination of properties you need, no matter what the application, there is theoretically one best steel for the job. Finding it among the great family of Carbon, High Strength, Alloy and Stainless Steels can be a problem unless you have a skilled metallurgist on your staff, or unless you take advantage of the free services of a company that has invested hundreds of millions of dollars in steel research–this is United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

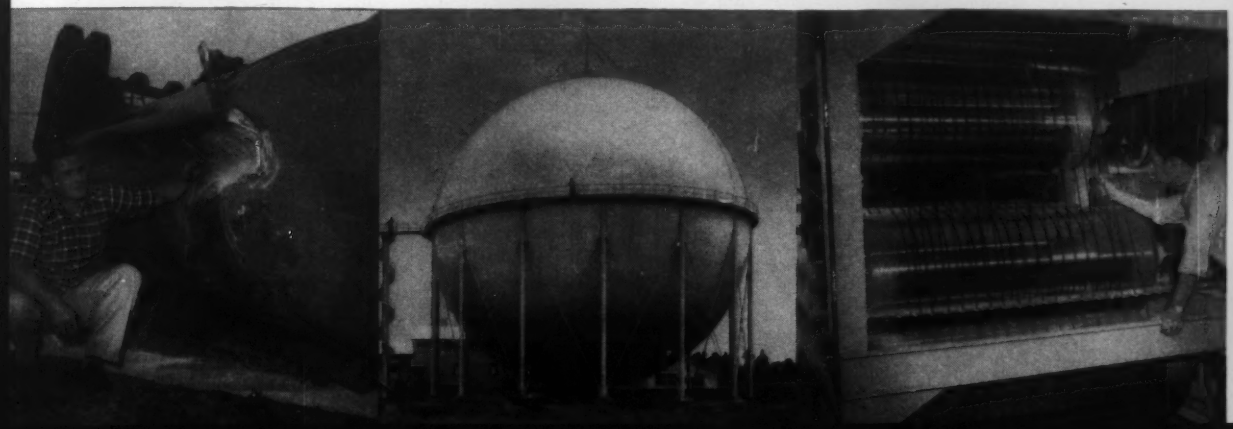
STEELS FOR DESIGN

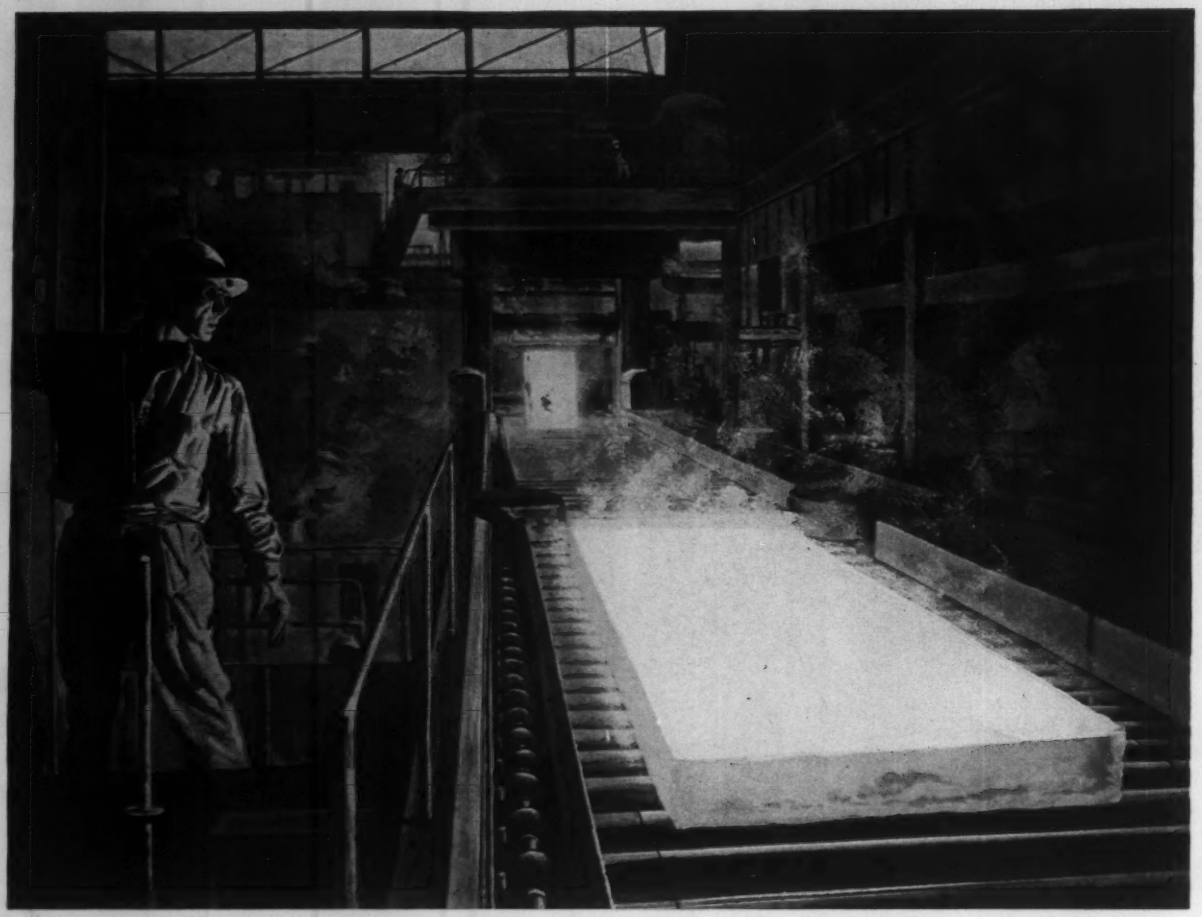
Lower Left—Problem: Combine maximum pay load and safety in gasoline tank trailer. Solution: Tuttle Mfg. Co. in Los Angeles recommended USS COR-TEN High-Strength Low-Alloy Steel, well known for its ability to increase pay loads without sacrificing strength or reliability. Pay-off: Entire side of tank was caved-in in freeway crash, but the COR-TEN Steel didn't crack or tear. Cargo was saved and possibility of fire averted.

Lower Middle—Problem: Build completely reliable high-pressure natural gas storage vessels for Tokyo Gas Works Ltd. and save on steel. Solution: Vessels were built from USS" T-1" Constructional Alloy Steel. Plates were cold-formed and welded with a 90% joint efficiency factor. Pay-off: Due to the high allowable working stress (36,000 psi), they saved 1,720 tons of steel.

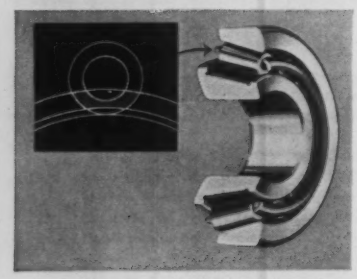
Lower Right—Problem: Design for a textile plant a 100% continuous steam process for vat dyeing that would insure exact color fidelity. Solution: Stainless Steel—its dense surface insures ease of cleaning, complete absence of color contamination. Pay-off: With the old equipment, dyeing was limited to one shade because it couldn't be adequately cleaned. The new Stainless equipment simply needs to be flushed out with hot water and it is clean enough for a new color.

USS, "T-1" and COR-TEN are registered trademarks





Bearings "keep cool" under hot steel!



HIGHER FLANGE IMPROVES ROLLER ALIGNMENT

As shown by the gray area above, the higher flange provides a large two-zone contact area for the roller heads. This greatly reduces wear—practically eliminates "end play". Larger oil groove provides positive lubrication.

Watch it! Coming down the line—another half-formed slab of red-hot steel! And with it comes a supreme test of bearing excellence. Bower Bearings are equal to it—helping to keep this mill operating smoothly and continually despite heavy loads and extreme temperature. Whatever the job, there's a Bower Bearing engineered to perform just as dependably when the going is toughest. Rigid quality controls and basic bearing design refinements like those shown at the left have reduced Bower Bearing failure to a practical minimum. If your product uses bearings, specify Bower! There's a complete line of tapered, straight or journal roller bearings for every field of transportation and industry.

BOWER ROLLER BEARING DIVISION
FEDERAL-MOGUL-BOWER BEARINGS, INC. • DETROIT 14, MICHIGAN

BOWER ROLLER BEARINGS

Circle 479 on Page 19

MACHINE DESIGN

November 13, 1958

Babbage's Dream

REPETITIVE calculation was aptly described by Charles Babbage, almost a century and a half ago, as "one of the lowest operations of the human intellect." What he described as "intolerable labour and fatiguing monotony" is worse than that in today's complex engineering work. It is economically unjustified and impossibly slow.

With computing machines now available far beyond the capacity of Babbage's wildest dreams, the human intellect need no longer be employed at such low levels. It is too badly needed at higher levels. The American Society for Engineering Education's report on *The Engineering Sciences* has something to say about one of these higher levels—design.

Under "Engineering Analysis and Design" the report repeatedly stresses the three essential ingredients of top-level design—analysis, synthesis, and evaluation. Likewise the report clarifies two commonly misinterpreted terms: "Engineering analysis . . . is not synonymous with mathematics . . . although mathematics is an essential tool" and, "design does not necessarily mean something associated with drafting."

How many engineering graduates shy away from design just because of one or both of these misconceptions? For such attitudes the professors themselves are often to blame. The neat, orderly, classroom approach of mathematical analysis seldom gives the one right answer to a practical design problem.

The powerful techniques of mathematical analysis are now, more than ever, needed as guideposts to design and as aids to judgment. But they can't make engineering decisions.

Today, mechanized calculation has tremendously widened the scope of mathematical investigation. It has also released the higher intellect for more creative activity.

Top-level design engineers, thanks to Mr. Babbage's successors, can expect increasing freedom to concentrate on the things that characterize creative design, such as evaluation and decision. Popular terminology notwithstanding, machines won't replace that kind of brainpower.

Colin Carmichael

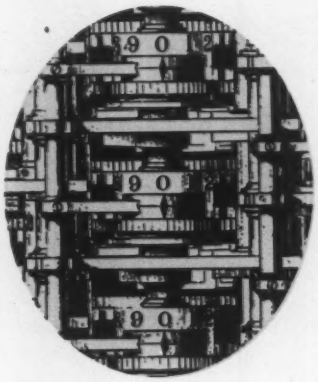
EDITOR

Mr. Babbage's Calculating

Modern computers — man-made brains that are revolutionizing business, industry, and research—work their wonders with the aid of fruits of recent electrical and electronic research. But 125 years ago, long before electricity became a practical tool, an Englishman named Charles Babbage conceived machines to automatically perform computations that would be ambitious even today.

Measures of the genius of Charles Babbage may be found in his concepts of computers controlled and operated entirely by mechanical means, and in the detailed plans he developed for building such machines. Not until the age of electricity and electronics did scientists again attempt a machine to perform so many complex operations.

Construction of even a mechanically actuated computer represented a near-insuperable problem in the early 1800s. Many of the parts Babbage needed were not in existence. He had to devise, not only components, but the very machines to make them. Nor was it easy to obtain competent workmen to help him assemble the computer. Under such difficulties, it is indeed remarkable that Babbage was able to complete his prototype "Difference Engine" by 1822 and to progress as far as he did during the next ten years toward completion of his full-scale model.



By RODNEY R. ADLER
The Burndy Library
Norwalk, Conn.

Engine

"There is no reason why mental as well as bodily labour should not be economized by the aid of machinery. The application of machinery to the most complicated and abstruse calculations can no longer be deemed unworthy of the attention of the country."

—Charles Babbage (1782-1871)

CHARLES BABBAGE became interested in performing mathematical computations by machinery shortly after he entered Cambridge at the age of 18 in 1810, and never abandoned his efforts until his death in 1871. At the University, Babbage joined with his fellow student John Herschel, son of the famous astronomer William Herschel and who later made his own mark in astronomy, to form the Analytical Society. The two mathematics enthusiasts found a number of errors in tables prepared for the Royal Astronomical Society.

"One evening in 1812 or 1813," Babbage related many years later, "I was sitting in the rooms of the Analytical Society, my head leaning forward on the table in a dreamy mood, with a table of logarithms lying open before me. Another member, seeing me half asleep, called out, 'Well, Babbage, what are you dreaming about?' to which I replied, 'I am thinking that all these tables (pointing to the logarithms) might be calculated by machinery.'"

What impressed Babbage was the great chance for error in performing the computations and transcribing the results and the time and effort required. As he explained in 1822 in a letter to Sir Humphry Davy, president of the Royal Society, "The intolerable labour and fatiguing monotony of a continued repetition of similar arithmetical calculations, first excited the desire, and afterwards suggested the idea, of a machine, which, by the aid of gravity or any other moving power, should become a substitute for one of the lowest operations of the human intellect."

▶ An Early Mechanical Brain

To demonstrate the principle he proposed, Babbage built a model of his "Difference Engine" with 18 wheels, able to compute results up to five places. Sponsored by Humphry Davy, he won government aid to design and construct a full-size machine, able

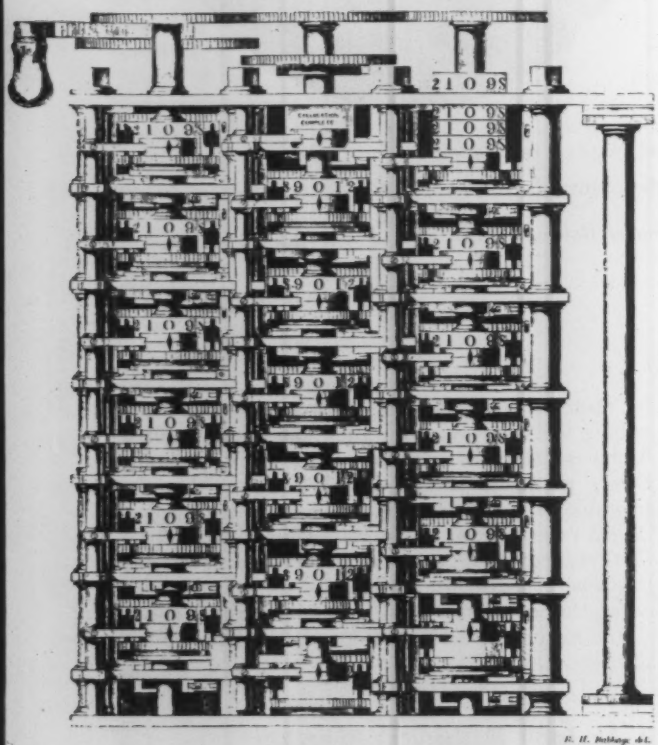
to handle numbers with as many as 20 digits.

"Nearly all tables of numbers which follow any low may be formed by successive addition and subtraction," Babbage told his nontechnical contemporaries. Taking the table of squares (1, 4, 9, 16, etc.) as an example, he showed that the differences (3, 5, 7, etc.) between terms increased in arithmetic progression, and that the difference between the differences (the "second difference") was constant, in this case, 2. "The mechanical execution of an engine to produce this series of numbers, is not so far removed from that of ordinary machinery."

An arrangement of "repeater" clocks, familiar to 19th century readers, provided an analogy for the Difference Engine's action. In modern terms, the Engine was similar to a series of adding machines coupled together. To compute a table of squares or logarithms, for instance, Babbage would manually find the differences between successive terms, differences between differences, and so on until he found a constant difference for the Engine.

Verification of results would be simple. "If proper numbers are placed at the outset in the Engine, and if it has completed a page of any kind of table, then by comparing the last number it has set up with that number previously calculated, if they are found to agree, the whole page must be correct. Should any disagreement occur . . . the shortest plan would be to make the Engine recalculate the whole page, and nothing would be lost but a few hours' labor

Repetitions of Process.	Movements.	Clock A. *Hand set to* I.	Clock B. *Hand set to* III.	Clock C. *Hand set to* II.
		TABLE.	*First difference*	*Second difference*
1	Pull A.	A. strikes 1	. . . . .	. . . .
	— B.	The hand is advanced (by B.) 3 divisions . .	B. strikes 3	. . . .
	— C.	. . . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
2	Pull A.	A. strikes 4	. . . . .	. . . .
	— B.	The hand is advanced (by B.) 5 divisions . .	B. strikes 5	. . . .
	— C.	. . . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
3	Pull A.	A. strikes 9	. . . . .	. . . .
	— B.	The hand is advanced (by B.) 7 divisions . .	B. strikes 7	. . . .
	— C.	. . . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
4	Pull A.	A. strikes 16	. . . . .	. . . .
	— B.	The hand is advanced (by B.) 9 divisions . .	B. strikes 9	. . . .
	— C.	. . . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
5	Pull A.	A. strikes 25	. . . . .	. . . .
	— B.	The hand is advanced (by B.) 11 divisions .	B. strikes 11	. . . .
	— C.	. . . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2
6	Pull A.	A. strikes 36	. . . . .	. . . .
	— B.	The hand is advanced (by B.) 13 divisions .	B. strikes 13	. . . .
	— C.	. . . . .	The hand is advanced (by C.) 2 divisions . .	C. strikes 2



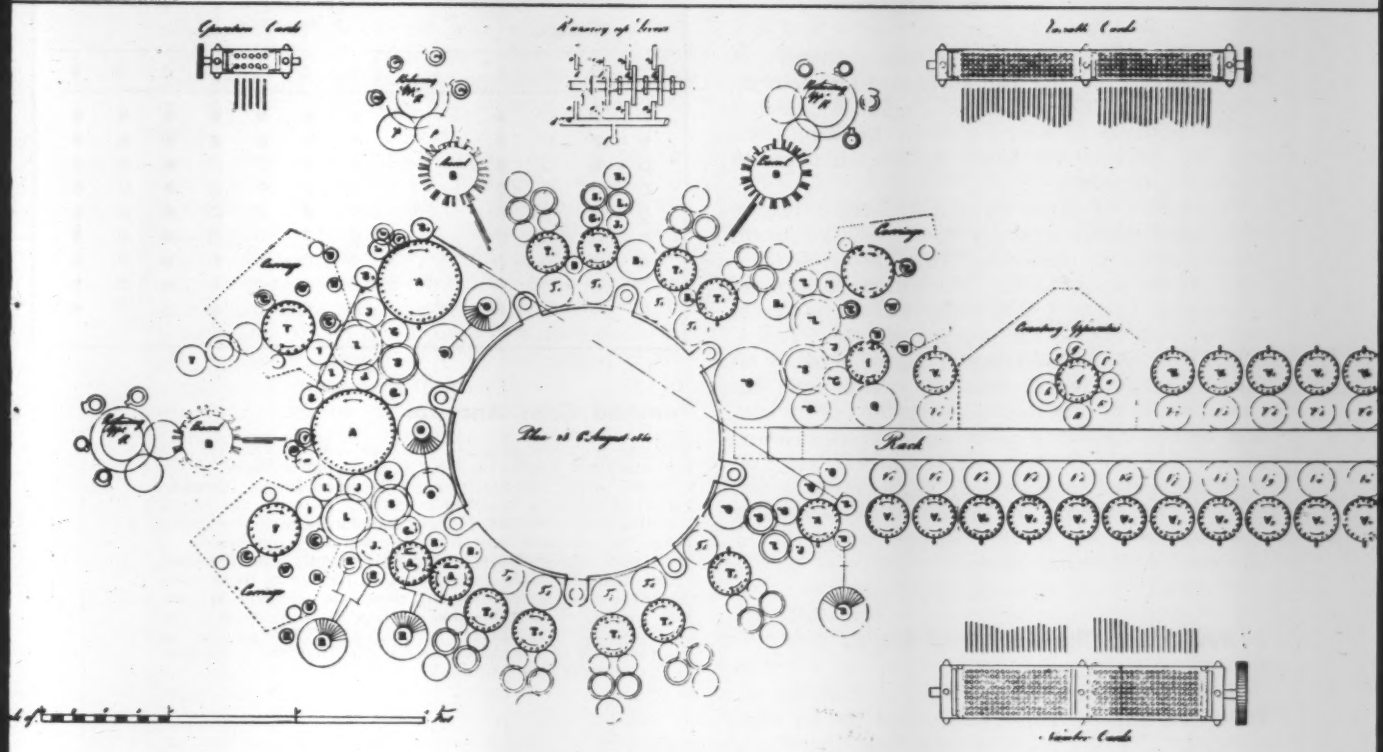
Inside the Difference Engine

A woodcut of the Difference Engine built by Babbage between 1823 and 1833. "The Difference Engine," Babbage wrote, "consists of three columns, each with six cages; each cage contains one figure wheel." Figure wheels in the right-hand column were set by hand for the table to be computed. Babbage explained the machine's operation by analogy with a series of "repeater" clocks.

Computing with Clocks

To understand the Difference Engine, Babbage asked his readers to ". . . imagine three (repeater) clocks, side by side, each having only one hand, and a thousand divisions instead of twelve hours on the face." Repeater clocks would strike the hour whenever a string was pulled, to tell time in the dark before the advent of the luminous dial.

"Suppose two of the clocks, *B* and *C*, have some mechanism by which clock *C* advances the hand of clock *B* one division, for each stroke of its own bell; and let *B* . . . similarly advance the hand of *A* one division for each stroke of its own bell. Set the hand of *A* to 1, *B* to 3, and *C* to 2." Pulling the string of each clock in turn would make *C* strike twice, advancing by two divisions the hand of *B* which would, in turn, strike three times and advance the hand of *C* from 1 to 4. From the table, it can be seen that the successive strikings of clock *C* would reproduce, mechanically, the table of square numbers.



The General Plan of
Mr. Babbage's Great Calculating Engine

The Analytical Engine

One of the many plans Babbage drew for his Analytical Engine. Using punched cards, it was to perform complex arithmetic and algebraic operations in predetermined sequence, and print its results or punch them on cards for further computation. It would have two main sections: 1. The "store," in which all the variables to be operated upon, as well as all those quantities which have arisen from the result of other operations are placed. 2. The "mill," into which quantities to be operated upon are brought.

of the moving power."

Faulty transcription and inaccurate computation caused many errors in published tables, Babbage recognized. Some 50 years before the first practical typesetting machines, he hoped to assure accuracy when he ". . . contrived means by which the machines themselves shall take from several boxes containing type, the numbers which they calculate, and place them side by side; thus becoming at the same time a substitute for the compositor and the computer, by which means all error in copying as well as in printing is removed."

The Project Stalls

The British government in 1822 promised financial support for labor and materials to build the engine, and Baggage offered to make drawings and supervise construction without compensation. He estimated that a full-size machine would weigh about 2 tons, and take two or three years to build at a cost of £3000 to £5000.

But 10 years later, the machine was still unfinished; the government had spent £17,000 and Babbage out of his own fortune £13,000. "Early in 1833," Babbage explained, "a small portion of the machine was put together, and was found to perform its work with all the precision which had been anticipated. At that period, circumstances, which I could not control, caused what I then considered a temporary suspension of its progress."

The "circumstances" he refers to included a misunderstanding with the engineer in charge of construction. The suspension was not to be temporary.

After vainly attempting to reach an agreement with the engineer, Babbage in 1834 appealed to the prime minister, the Duke of Wellington. Before the Duke could give a decision, his government was out of office. Ministry succeeded ministry and for eight years the Difference Engine was subordinated to more conventional political issues. Finally, in 1842, Peel's chancellor of the exchequer notified Babbage that the government regretted the necessity of abandoning the machine because of the expense required for its completion.

By the time work ceased, the Difference Engine had grown to a complex assemblage about as large

as a barrel, able to perform a limited number of the operations Babbage had envisioned for the complete machine. The unfinished Engine was placed in the museum of King's College, London, 1843, and has been in the South Kensington Museum (London) since 1862.

Publication of plans for the Difference Engine encouraged similar attempts by Babbage's contemporaries. One of these was "Mr. Scheutz, an eminent printer at Stockholm. He undertook to make a machine having 4 differences and 14 places of figures, and capable of printing its own Tables. After many years' indefatigable labour, and an almost ruinous expense, aided by grants from his Government, by the constant assistance of his son, and by the support of many enlightened members of the Swedish Academy, he completed his Difference Engine. An exact copy of this machine was made by Mr. Donkin for the English Government, and is now in use in the Registrar-General's Department at Somerset House."

New Start: The Analytical Engine

In 1834, during the suspension of work on the Difference Engine, Babbage conceived the far more ambitious idea of a machine to perform almost any mathematical operation and to solve series of problems "programmed" in advance.

"It will calculate the numerical value of any algebraical function," Babbage wrote of his newer conception, the Analytical Engine. "At any period previously fixed upon, or contingent on certain events, it will cease to tabulate that algebraic func-

THE BURNDY LIBRARY: Dedicated to the history of science and technology, the Burndy Library, Norwalk, Conn., is a nonprofit institution chartered by the State of New York. The library owns more than 10,000 original manuscripts, pamphlets, engravings, books, other records and publications, as well as early electrical machines and other scientific apparatus which are historic landmarks in the development of today's mechanized civilization.

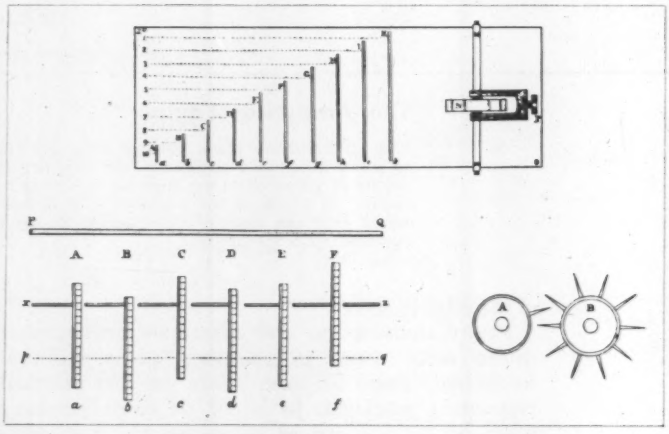
Part of the story of Babbage's pioneering attempt emerges from a collection of 15 papers he published between 1815 and 1864, recently added to the Burndy Library. These and other original works of Babbage in the library tell of his lifelong struggle to create a completely automatic computer more than a century ahead of its time.

Bern Dibner, director of the library, is an engineer who holds several patents, an active industrialist who has helped build a multimillion dollar manufacturing business, and a science historian. In the last field he has published such books as Agricola on Metals, Early Electrical Machines, Moving the Obelisks, and Heralds of Science.

Number.				Table.						
2	3	0	3	3	6	2	2	9	3	9
●	●	○	●	●	●	●	●	●	●	●
●	●	○	●	●	●	●	●	●	●	●
○	●	○	●	●	●	○	○	●	●	●
○	○	○	○	○	●	○	○	●	○	●
○	○	○	○	○	●	○	○	●	○	●
○	○	○	○	○	●	○	○	●	○	●
○	○	○	○	○	○	○	○	●	○	●
○	○	○	○	○	○	○	○	●	○	●
○	○	○	○	○	○	○	○	●	○	●

Punched Card Ancestor

Babbage proposed punched cards to feed information into his Analytical Engine and to program the sequence of operations, taking his cue from the Jacquard loom. "Availing myself of the same beautiful invention," he wrote the French scientist, Arago in 1839, "I have communicated to my engine orders to calculate any formula, however complicated. I have also advanced one stage further, and have communicated orders to follow certain laws in the use of those cards. Thus the engine can solve any equations, eliminate between any number of variables, and perform the highest operations of analysis." The "tabular number"—3622939— punched on the right side of the sample card is the logarithm (mantissa) of the "number" 2303 on the left.



How the Mill Worked

Mechanical details designed by Babbage for the "mill" of his Analytical Engine have become basic elements of modern calculators and computers. A digit could be added to any number in the mill by the arrangement at top. Ten ribs varying in length from *Aa* to *Kk* are soldered to a plate. Fork *P* positions toothed wheel *N* on square-section axis *Mm*. If fork *P* is set opposite 6, for example, and the wheel rolled clear across the plate, the wheel will turn through a space equivalent to six teeth and its motion is transferred to the mechanism of mill.

A number can be added to any sum already in the machine by correctly positioning racks *Aa*, *Bb*, etc. (lower left). When plate *PQ* is brought down against fixed plate *xz*, with holes for racks, spur gears (not shown) on shaft *pq* turn through the number of teeth depending on the positions of the racks. If the wheels on *pq* already stand at a number, say 543243, and the racks are set as shown to add 314236, the new sum will be 857479. Carrying can be accomplished with a discontinuous gear train (lower right) in which gear *B* will move 1/10 revolution for each revolution of single-tooth *A*.

tion, and commence the calculation of a different one, and that these changes may be repeated to any extent. The former (Difference) Engine could employ about 120 figures in its calculations; the present machine is intended to compute with about 4000."

The Analytical Engine would have a storage capacity of 1000 50-digit numbers and built-in logarithms and other tables. Assuming that the Analytical Engine's parts could move 40 fpm, Babbage estimated that "Sixty additions or subtractions may be completed and printed in one minute; one multiplication of two numbers, each of 50 figures, in one minute; and one division of a number having 100 figures by another of 50 in one minute." Provision would be made in the machine for ". . . printing its results on paper, producing a stereotype mould, and punching the results on pasteboard cards or metal plates . . . Of course the Engine will compute all the Tables which it may use."

Birth of Punched-Card Computing

Although he neglected electricity, Babbage did include an element common to many present-day computers, the punched card. He adapted this idea from the Jacquard looms invented a few years earlier and proposed to use punched cards both to feed arithmetic data into the "mill," and to instruct the machine where to store input and how to use output data.

There would be two kinds of cards, ". . . the first to direct the nature of the operations (arithmetic) to be performed—these are called operation cards; the other to direct the (algebraic) variables on which those cards are to operate—these latter are called variable cards." As in the Jacquard loom, cards would be strung together and fed into the mill in proper sequence for the operations to be performed on the desired variables.

"The Analytical Engine will possess a library of its own." Once a formula had been calculated and punched on cards, its numerical values could readily be obtained for any desired constants.

Babbage was never able to obtain financial support to build an Analytical Engine, although from 1834 to 1864 he completed 239 detailed engineering drawings for the machine, which was to have 50,000 parts. From Babbage's first-hand investigation of potential suppliers to manufacture special parts for his engines came a unique by-product: His book, *On the Economy of Manufactures and Machinery*. Published in 1832, and possibly the first work on industrial engineering, it analyzed the economics and technology of industries of the day.

Computing: Before and After Babbage

Charles Babbage was one of the most brilliant, but he was far from the first man of science to seek mechanical aids to computation. That quest began with the unnamed ancient who invented the abacus, and continued through history to engage the attention of a number of outstanding minds.

One of them was John Napier, the Scotsman who about 1600 used sliding rods calibrated with numbers to simplify calculations and later invented a system of logarithms. Because the rods were often made of bone, his device was called "Napier's Bones."

In 1642 Blaise Pascal, famous French mathematician and philosopher, built a calculator which may be considered the earliest member of the "digital" class, to which belong Babbage's machines and most of the computers used today in business. The slide rule, invented in 1650 by William Oughtred, an Englishman, fathered the "analog" family of computers, which physically simulate the mathematical problem to be solved and are today proving extremely helpful in scientific research.

Gottfried Wilhelm Leibniz, the German philosopher who developed calculus simultaneously with Isaac Newton, built a digital calculator in 1673. He was the first to advocate a binary system of numeration, which uses only two rather than ten numbers. Binary numbers, represented by the on or off positions of flip-flop vacuum tubes or transistors, have greatly simplified modern computers.

The workable calculators that appeared as early as the 17th century were simple adding machines and did not approach the involved operations of Babbage's engines, or of modern computers. Where Babbage failed of full achievement, Pascal and his contemporaries succeeded because their more limited aims could be realized with existing skills and at reasonable expense.

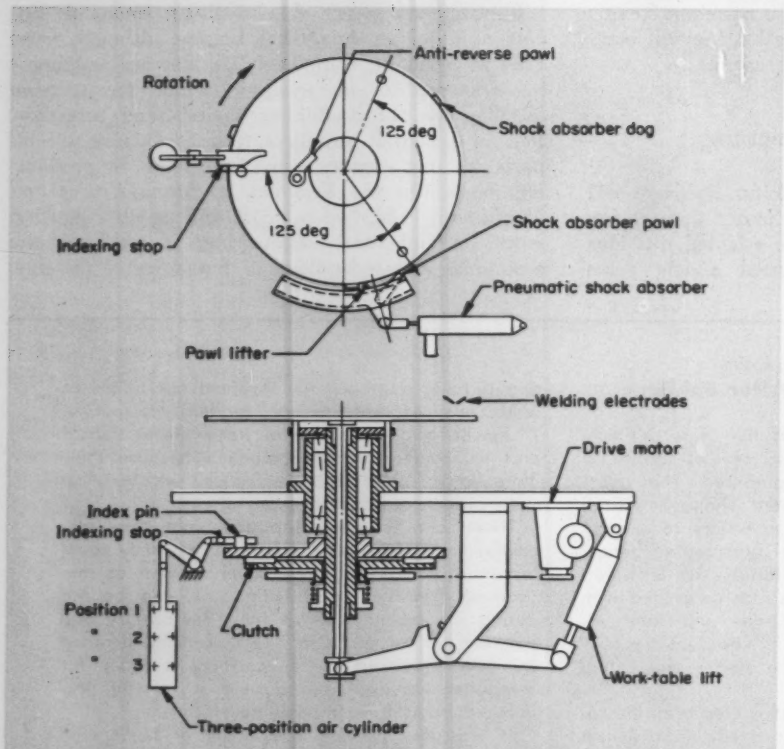
Those who followed Babbage were more successful for at least two reasons. First, they could draw on a technology, electrical as well as mechanical, that advanced with leaps and bounds during the second half of the 19th century and the first half of the 20th. Second, rising demand by government, business, and the military for computing services opened new sources of economic support for computer development.

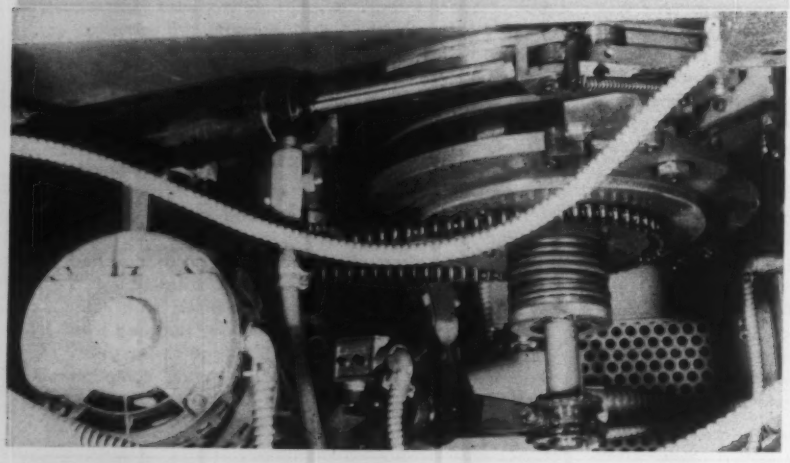
It was the growing complexity of the United States decennial census and the increasing number of special censuses at more frequent intervals that hastened the development of practical punched-card electric tabulating equipment. Recognizing that results of the 1890 census could not be tabulated by manual methods by the time the next count was due, the Census Bureau asked Dr. Herman Hollerith of Buffalo to devise a better system. He responded by developing equipment which used tape punched with holes representing census data to close circuits and actuate electric sorting and adding machines.

Later the tape was replaced by cards punched according to a code capable of transcribing a wide range of information. Combined with electromagnetic or electronic calculators, punched-card equipment—anticipated by Babbage's Analytical Engine—is an essential part of many computer assemblies.

scanning the field for *ideas*

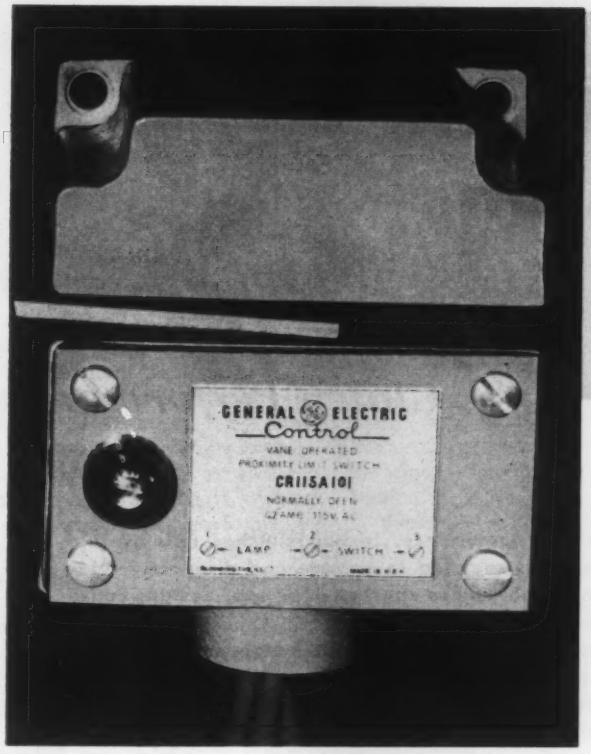
Nonuniform rotary indexing motions

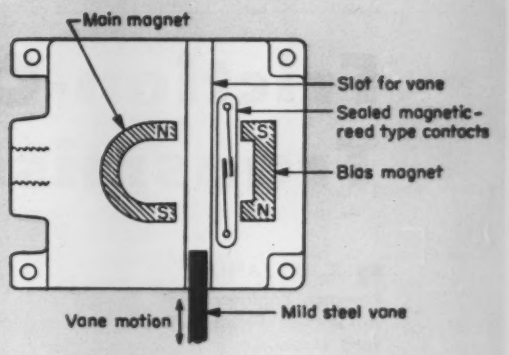




are controlled by a three-stage air system. In a high-speed sequential - welding mechanism designed by M. Van Renssen of Radio Corp. of America, operation of three independent air cylinders is phased to provide adjustable control of dwell time and index position. In a typical welding sequence, the rotary turret is programmed to produce indexes of 5, 120, 5, 120, 5, and 105 degrees.

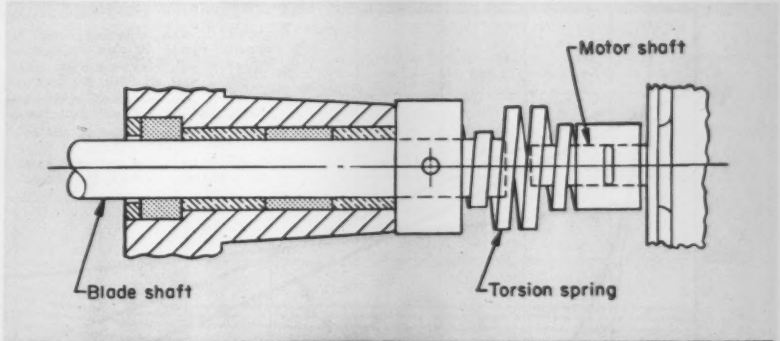
The amount of indexing is determined by the spacing of stop pins on the top of the turret and by the position of the indexing stop which is controlled by a three-position air cylinder. A second cylinder and linkage raises and lowers the work table and controls the dwell times preceding large indexes. Deceleration of the turret during large indexes is provided by a pneumatic shock absorber which is actuated by dogs mounted on the periphery of the turret.

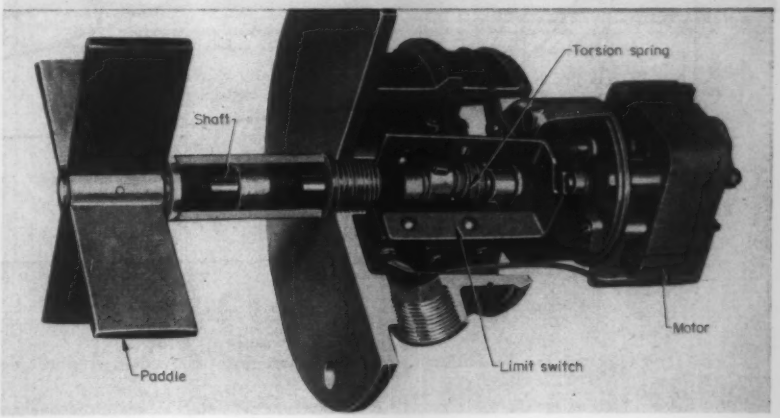




Magnetic springs operate switch contacts when triggered by a movable metal vane. In a normally open limit switch designed by General Electric, sealed magnetic-reed type contacts lie between two permanent opposing magnets. As a metal vane is moved through a slot in the housing, it passes between the two magnets, shunting the main magnetic field through the vane. At the same time, a field is set up between the bias magnet and the reeds, closing contacts and completing circuit.

Torsion-spring coupling expands when overloaded and activates limit switch to stop motor rotation. In Convair's Bin-Vue level indicator, a fractional hp motor drive is coupled to a blade-paddle shaft by a torsion spring. When the paddle is stopped, continued rotation of the motor expands the spring, activating the limit switch to kick out the motor. When the paddle is released, the torsion spring reactivates the paddle and contracts from the limit switch, starting the motor and putting the unit in operation.





Friction-Clutch Transmissions

Part 1 Factors in Clutch Performance

By Z. J. JANIA
Research Engineer
Automotive Research Dept.
Ford Motor Co.
Dearborn, Mich.

Keystone-like in function and importance, friction clutches reliably join the elements of power transmissions required to engage and disengage relatively frequently. They're cranky, too—these clutches—for poor designs cause a host of troubles, like chatter and burn-out.

These results need not occur if clutch capacities and burdens are balanced in the design stage. How to strike this balance is the content of a new series of articles on friction clutch transmissions.

First in the series, this article analyzes the performance of friction clutches and systems, with particular attention to the problem of vibration. It concludes that torsional vibration can be prevented by changes in one or more of three important factors: Shaft stiffness, the inertia of components, and the friction-speed characteristics of the clutch face material.

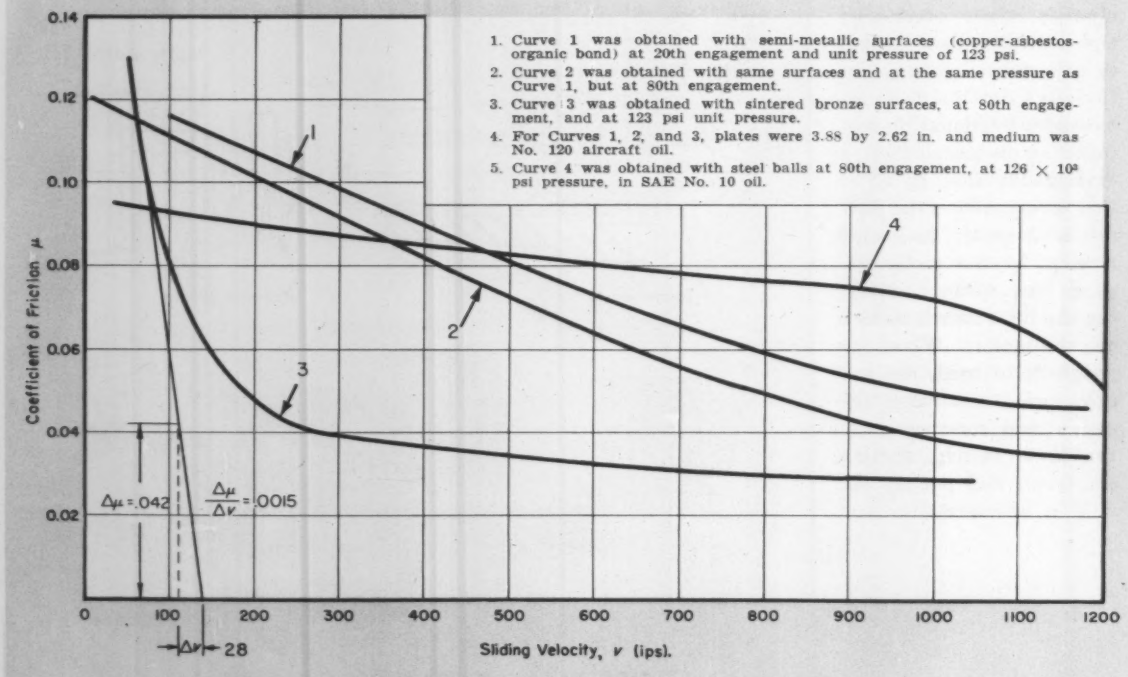

1. Curve 1 was obtained with semi-metallic surfaces (copper-asbestos-organic bond) at 20th engagement and unit pressure of 123 psi.
2. Curve 2 was obtained with same surfaces and at the same pressure as Curve 1, but at 80th engagement.
3. Curve 3 was obtained with sintered bronze surfaces, at 80th engagement, and at 123 psi unit pressure.
4. For Curves 1, 2, and 3, plates were 3.88 by 2.62 in. and medium was No. 120 aircraft oil.
5. Curve 4 was obtained with steel balls at 80th engagement, at 126 × 10³ psi pressure, in SAE No. 10 oil.
Coefficient of Friction μ
0.14
0.12
0.10
0.08
0.06
0.04
0.02
1
2
3
4
Δμ = .042
Δμ/Δv = .0015
Δv = 28
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
Sliding Velocity, v (ips).

Fig 1—Sliding coefficient of friction obtained in flywheel deceleration tests

CHATTER from a clutch should be fair warning of imbalance between its operating factors. In redesign or original design, a prime objective is the matching of these quantities. Forces that comprise clutch load are due to inertia, compliance, viscous friction, and coulomb friction throughout the power-transmission system. Whether these loads are applied slowly or suddenly, the clutch should be designed to operate without vibration.

To assure this performance, the dependence of frictional clutch torque on slip speed must be examined. In general, clutch torque capacity is also a function of the temperature of the contacting surfaces and the pressure between them. In the case of "wet" clutches, lubrication is an additional factor.

Clutch Capacity

For the moment, pressure may be assumed to remain sensibly constant during the engagement

Nomenclature

c = Constant
F_1 = Viscous friction force, lb
F_2 = Coulomb friction force, lb
I = Moment of inertia, lb-in.-sec^2
K = Shaft stiffness, lb-in. per rad
k_1, k_2 = Constants
M = Mass, lb
m = Slope of friction-velocity characteristic curves
n = Number of clutch friction surfaces
P = Total axial load, lb
p = Unit axial load, psi
R_i, R_o = Clutch face radius, inside and outside, in.
r = Radius, in.
T = Frictional moment; transmitted torque, lb-in.
T_n = Total frictional moment for n surfaces, lb-in.
T_0 = Torque to overcome static friction load, lb-in.
t = Time, sec
v = Linear, tangential velocity, ips
x_1, x_2 = Linear displacement, flywheel and clutch ends of a shaft, in.
β = Slope of torque-velocity curve
θ_1, θ_2 = Angular displacement, flywheel and clutch ends of a shaft, rad
λ_1, λ_2 = Roots of velocity equation
μ, μ_0 = Coefficients of friction, dynamic and static
Ω = Angular velocity under specified conditions, rad per sec
ω_1 = Angular velocity, flywheel end of shaft, rad per sec
ω_i, ω_o = Angular velocity, input and output, rad per sec
$\omega_r = \omega_i - \omega_o$

Note: First and second derivatives are designated by prime and double-prime exponents.

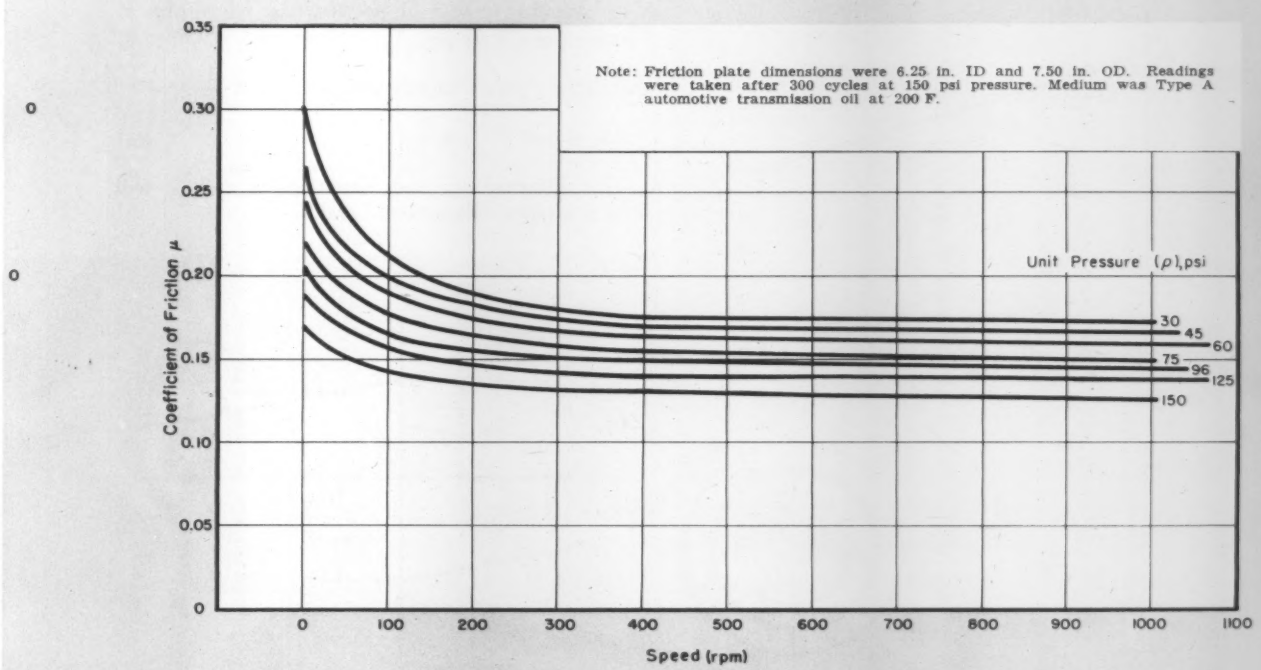


Fig. 2—Coefficient of friction obtained on cork friction surfaces in flywheel deceleration tests

period. Also, the effect of transient temperature variation on friction may be considered to be included in the variation of friction with sliding velocity. Fig. 1 and 2 illustrate this variation for representative friction materials used by the automotive industry. The graphs show that coefficient of friction decreases with relative sliding velocity. For some materials, this variation may be approximated with a straight line having negative slope. This relationship, somewhat idealized, is shown in Fig. 3.

The slope of the line, $m = -\Delta\mu/\Delta v$, indicates the dependence of friction on sliding velocity, and can be written

$$\mu = \mu_0 - mv \tag{1}$$

To determine how this characteristic of friction materials influences the torque capacity of a friction clutch, examine Fig. 4. From that diagram, the load supported by the strip of width dr is

$$dP = 2\pi\, pr\, dr$$

Hence,

$$P = 2\pi \int_{R_i}^{R_o} pr\, dr \tag{2}$$

Similarly, the frictional moment, due to the tangential force acting on the elemental strip dr, is

$$dT = 2\pi\, \mu\, pr^2\, dr$$

Hence,

$$T = 2\pi \int_{R_i}^{R_o} \mu\, pr^2\, dr \tag{3}$$

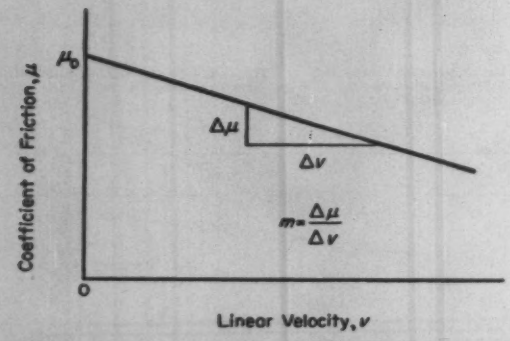


Fig. 3—Relationship of coefficient of friction, μ, and linear velocity, v, idealized as a straight line

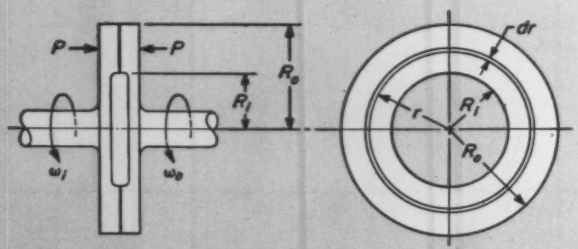


Fig. 4—Elements of a friction clutch

Before Equations 2 and 3 can be integrated, the manner in which μ and p vary with respect to the radius must be known.

Friction Coefficient Variation: From Fig. 4, the tangential relative velocity at radius r is

$$v = (\omega_i - \omega_o)r \tag{4}$$

and this expression is substituted in Equation 1, which becomes

$$\mu = \mu_o - m(\omega_i - \omega_o)r \tag{5}$$

Unit Pressure Variation: There is considerable uncertainty about the distribution of axial load P over contact surfaces. Between surfaces made of frictional materials such as sintered bronze and copper-asbestos material, contact is far from uniform. Therefore, pressure distribution over the contact area is highly irregular. When friction surfaces are made of resilient materials, such as cork or mixtures of asbestos and wood flour, fairly uniform contact can be assumed. Therefore, pressure will not depend on the radius.

Moreover, when clutch life is considered, the rate at which surfaces wear depends not only on the *intensity* of pressure but also on the *velocity* of rubbing between the surfaces. That is,

$$\text{Rate of wear} = f\ (p, v)$$

Since there is little information available as to the exact relationship between the rate of wear, intensity of pressure, and rubbing velocity, it is assumed that rate of wear is directly proportional to the product pv. Thus,

$$\text{Rate of wear} = k_1\, pv \tag{6}$$

and, since v varies directly with r,

$$\text{Rate of wear} = k_2\, pr \tag{6a}$$

This information, and Equations 4 and 5, will help to integrate Equations 2 and 3.

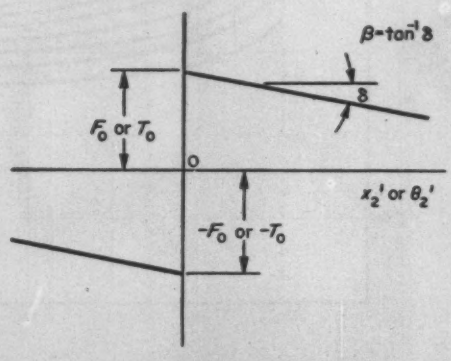


Fig. 5—Variation of frictional torque with slip velocity

Frictional Moment (a): In this derivation, pressure p is considered uniform, and the coefficient μ varies linearly with tangential rubbing speed v. Equation 2 is integrated

$$P = 2\pi p \int_{R_i}^{R_o} r\,dr = \pi p(R_o^2 - R_i^2) \tag{7}$$

Values for μ and p from Equations 5 and 7 are substituted in Equation 3. The integrated result is

$$T = \frac{2}{3} P \mu_0 \left(\frac{R_o^3 - R_i^3}{R_o^2 - R_i^2} \right) - \frac{1}{2} Pm(R_o^2 + R_i^2)(\omega_i - \omega_o) \tag{8}$$

For a clutch having n pairs of frictional surfaces in contact, the frictional moment is

$$T_n = Tn \tag{9}$$

Frictional Moment (b): In this derivation, rate of wear is considered uniform ($pr = c$), and the coefficient μ varies as in derivation (a). In this case the integration of Equation 2 results in

$$P = 2\pi c \int_{R_i}^{R_o} dr = 2\pi c(R_o - R_i) \tag{10}$$

Values for μ and p from Equations 5 and 9 are substituted in Equation 3, and the integrated result is

$$T = 2\pi c \left[\frac{1}{2} \mu_0 (R_o^2 - R_i^2) - \frac{1}{3} m(\omega_i - \omega_o)(R_o^3 - R_i^3) \right] \tag{11}$$

The expression for c, derived from Equation 10, is substituted in Equation 11 which becomes, for n pairs of friction surfaces,

$$T = \frac{1}{2} P \mu_0 n(R_o + R_i) - \frac{1}{3} Pnm \left(\frac{R_o^3 - R_i^3}{R_o - R_i} \right) (\omega_i - \omega_o) \tag{12}$$

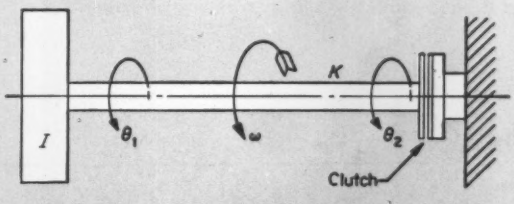


Fig. 6—Simple dynamic system, including a friction clutch

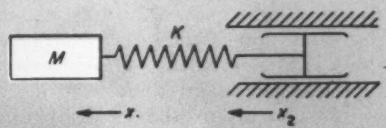


Fig. 7—Translational system analogous to system in Fig. 6

Equations 9 and 12 are of interest in subsequent work. They both have the form

$$T = T_0 - \beta(\omega_i - \omega_o) \tag{13}$$

or

$$T = T_0 - \beta\omega_r \tag{14}$$

Equations 13 and 14 are represented graphically in Fig. 5.

For clutch plates in which R_o is not much larger than R_i—say $R_o/R_i = 1.25$ to 1.35—it can be shown that Equations 9 and 12 give values which, for all practical purposes, are the same.

Which of these two expressions should be used in any given problem depends on which of the two assumptions—uniform pressure distribution, or constant and uniform rate of wear—better approximates expected operating conditions. In any case, the frictional moment calculated with Equation 12 is slightly lower than that obtained from Equation 9. To be on the safe side, Equation 12 seems better suited for computation of torque capacity.

Example: To illustrate the effect of the two assumptions, let $R_o = 3.00$; $R_i = 2.30$; $n = 8$; $\mu_0 = 0.12$; $m = 10^{-4}$.

Then, by Equation 9,

$$T_n/P = 2.56 - 5.71 \times 10^{-3}\,\omega_r$$

and, by Equation 12,

$$T_n/P = 2.54 - 5.65 \times 10^{-3}\,\omega_r$$

Systems Performance

A simple dynamic system which employs a friction clutch is shown in Fig. 6. Shaft and flywheel rotate at a uniform angular velocity prior to the application of the friction clutch which in this case acts as a brake. Fig. 7 shows an analogous translational system.

There will also be some viscous resistance present in systems, due in part to lubricated bearings. From this consideration, and from the information in Fig. 7, the equation of motion for mass M is

$$Mx'' + F_1 x_1' + K(x_1 - x_2) = 0 \tag{15}$$

Similarly, the motion of the slider is

$$-K(x_1 - x_2) \pm F_2(x_2') + F_1(x_2') = 0 \tag{16}$$

Here, $F_2(x_2')$ is the coulomb friction force opposing the motion of the slider. The $\pm$ sign indicates that this force is negative when slider velocity is positive, and positive when velocity is negative. That is, it always opposes motion regardless of direction.

In the case of the rotating flywheel, Fig. 6, the torque due to the friction clutch can be expressed

$$\text{for positive } \theta_2',\ T = T_0 - \beta\theta_2' \tag{17}$$

$$\text{for negative } \theta_2',\ T = -T_0 + \beta\theta_2' \tag{18}$$

Thus, the simultaneous equations describing the mo-

tion of the two ends of the shaft, for positive θ_2', are

$$I\theta_1'' + F_1\theta_1' + K(\theta_1 - \theta_2) = 0 \quad (19)$$

$$-K\theta_1 + (F_1 + \beta)\theta_2' + K\theta_2 = T_0 \quad (19a)$$

$$-K\theta_1 + (F_1 - \beta)\theta_2' + K\theta_2 = -T_0 \quad (20)$$

Application of Equations 19 and 20 depends on whether θ_2' is positive or negative. When $\theta_2' = 0$, both equation pairs are equally valid.

Velocity Expressions: In this study of rotating systems, speeds are more important than angular displacements. Accordingly, the equations for displacement are transformed and solved for angular velocity directly. Derivation of an expression for ω_1 starts with Equation 19 in which θ_2 is eliminated to obtain a differential equation having only one dependent variable. The final expression is

$$\omega_1 t = KT_0\left[\frac{1}{\lambda_1,\lambda_2} + \frac{e^{\lambda,1,t}}{\lambda_1(\lambda_1 - \lambda_2)} + \frac{e^{\lambda,2,t}}{\lambda_2(\lambda_2 - \lambda_1)}\right] + a\Omega\left[\frac{\lambda_1 e^{\lambda,1,t}}{\lambda_1 - \lambda_2} + \frac{\lambda_2 e^{\lambda,2,t}}{\lambda_2 - \lambda_1}\right] \quad (21)$$

where the exponents λ, 1, t and λ, 2, t represent $\lambda_1 t$ and $\lambda_2 t$, respectively, and λ_1 and λ_2 are roots of the characteristic equation

$$(Ap^2 + Bp + C)\omega_1 = KT_0$$

Here, p indicates the derivative d/dt, and

$$A = (\beta + F_1)I$$

$$B = F_1(F_1 + \beta) + KI$$

$$C = K(2F_1 + \beta)$$

The roots are obtained by setting

$$Ap^2 + Bp + C = 0$$

From Equation 21, it is seen that the behavior of the system depends solely upon the nature of the exponents of e. If λ_1 and λ_2 are conjugate complex numbers with the real part negative, the system will oscillate, while $\omega_1 t$ approaches zero asymptotically. If λ_1 and λ_2 are both real negative numbers, there is no oscillation and the solution for ω_1 will contain hyperbolic functions.

To examine the roots λ_1 and λ_2 more closely, let $F_1 = 0$. It is usually small, and no loss of generality will result. Also, the terms β and F_1 are dimensionally equivalent. Then,

$$\lambda_1, \lambda_2 = \frac{-KI \pm [K^2I^2 - 4KI(\beta^2)]^{1/2}}{2I\beta} \quad (22)$$

At this point, it is noted that in order for the values of λ to be conjugate complex numbers, the following inequality must be satisfied:

$$\beta > \frac{1}{2}\sqrt{KI} \quad (23)$$

In this expression, β is the slope of the straight line in Fig. 5 which illustrates the variation of clutch frictional torque, T, with slip velocity, ω. If Equation 12 is used to express this same relationship, then

$$\beta = \frac{1}{3}Pnm\left(\frac{R_o^3 - R_i^3}{R_o - R_i}\right) \quad (24)$$

where m is the slope of the friction-speed characteristic of the friction material. This expression is substituted in Equation 23 to obtain

$$m > \frac{3(R_o - R_i)\sqrt{KI}}{2Pn(R_o^3 - R_i^3)} \quad (25)$$

The system will not oscillate unless Equation 25 is satisfied. This implies that the negative slope of the friction-speed characteristic shown in Fig. 5 for the clutch friction material must have a rather high numerical value before the system can be set in oscillation by the action of the clutch. This conclusion is consistent with the author's experience in the development of automotive transmissions. Conditions similar to those analyzed here, but more complicated, occur during the automatic-shift from "low" to "direct" gear. Clutches lined with friction materials having speed characteristics similar to Curve 3, Fig. 1, have been known to chatter under certain operating conditions. Subsequent tests disclosed that vibration occurred at the end of the shift period.

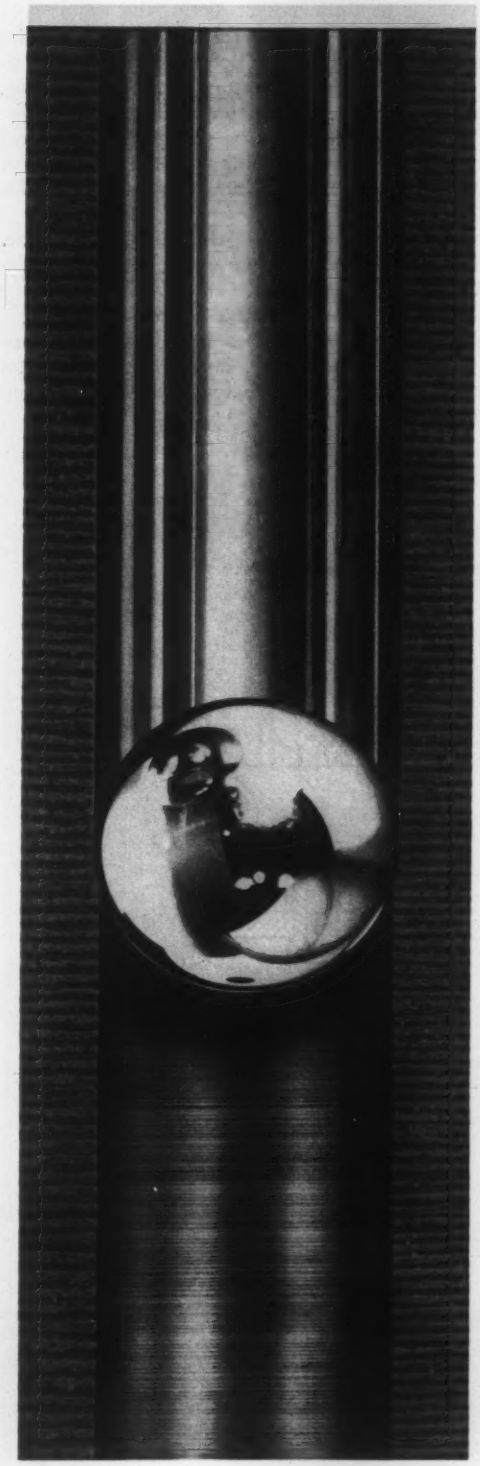
Example: To illustrate what values of m are likely to be encountered in practice, consider a system in which $K = 10^4$ lb-in. per rad, $I = 4.8$ lb-in.-sec^2, $P = 2000$ lb, $n = 8$, $R_o = 2.60$ in., and $R_i = 1.96$ in. The slope m is found to be 0.0013. From Fig. 1, the slope of Curve 3 at $v = 50$ in./sec is $\Delta\mu/\Delta v = 0.0015$. Thus, oscillations could be induced in this system just before the shaft and flywheel are stopped by the clutch.

The next article in this series shows how a complex transmission can be analyzed as a simple system having two inertia elements. The analysis points out the limitations on the addition of inertia to a system to obtain smoother operation of clutches and speed-change gears. Included is a discussion of oscillographic records of actual transmission tests.

They Say . . .

"Throughout the wide fields of engineering, the most fundamental requirement is a sound knowledge of the first principles of mechanics coupled with an intimate understanding of the properties of materials. More problems arise from weaknesses in mechanical design than from any other cause, impressing upon us the necessity of being well versed in the basic principles of mechanical engineering."—Sir George H. Nelson, *president, Institute of Electrical Engineers.*

BALLIZING



A versatile hole-finishing process that offers unusual possibilities for close control of finish and diametral tolerance. Design information in this article is by the engineering staff of Industrial Tectonics Inc., Ann Arbor, Mich.

BALLIZING is a modernized version of an old process. It is a hole-finishing method involving forcing a precision ball through a hole. Making close-tolerance holes is the usual objective. However, improved surface finish is always obtained as an extra bonus. In addition, refined grain structure of the hole-wall material is produced by the drastic cold-working.

How It Works: The process consists simply of pressing an oversize ball through an undersize hole. Balls are usually 0.0005 to 0.002 in. per in. of diameter larger than the high limit of the hole diameter to be finished. As the ball is forced through the hole, the hole wall is expanded. Part of the total expansion is a function of the elasticity of the wall material. After the ball has passed, the wall springs back by a lesser amount, since metal is displaced by plastic flow, and a portion of the initial wall deflection is permanent.

Ballizing can also perform mechanical locking of a tubular part within a hole, Fig. 1. For this application, the ball forces restricted portions of the ID of the tube outward as the ball passes through. This is similar to certain types of press operations in which a punch passes through a part to perform internal swaging. However, with ballizing, it is not necessary to retract the punch from the hole. This reduces scratches in the hole and tool wear is cut drastically since the punch always works, and wears, along one surface, while a ball will always present new surfaces.

Work Hardening: The radially acting force, derived from the interference fit between ball and hole, is normally insufficient to cause objectionable overall changes in the work-part dimensions. Yet, because this force is concentrated along a narrow line contact between the ball and wall of the hole, the supporting area is very small. Since the area is

small, the unit pressure is very high. Thus, in basic principle, ballizing is much like the penetration of a Rockwell diamond or the indentation of a Brinell ball. In each case, the unit pressure is high enough to cause plastic deformation of surface material to a shallow depth.

This plastic flow does not extend much below the surface. Due to the high concentration of stresses, the pressure gradient is very steep and, except for the first few thousandths of an inch in depth, the effect is of relatively small magnitude. The base material is distributed very little and acts somewhat as a receptive matrix into which tool marks, waviness, and other imperfections are pressed by the advancing ball. Thus, in effect, the initial surface characteristics are "turned inside out" and the hole assumes much of the ball's inherent smoothness.

The result of cold-working is usually highly desirable, but in any case, it must be accepted as an unavoidable part of the operation. Holes in materials which work-harden will have improved wear resistance and generally show less tendency to gall. In this respect, ballizing differs from other methods of hole sizing and finishing.

Hole Sizing: Drilled holes may be ballized to obtain some improvements in size uniformity. The amount of improvement will depend on amount of variation in the drilled holes.

If a reamed hole is ballized there will also be an improvement in uniformity. Again, the amount of improvement will depend on the amount of variation in the reamed condition. The same rule applies to honing and all other preparatory methods. Ballizing will always improve a hole, but it does not remove all of the initial defects. By proper selection and size control of the machined ID, tolerances of ± 0.0002 in. in a ballized hole are quite feasible, Fig. 2.

Material hardness, wall thickness, hole size, ductility, and like parameters are related in an exceedingly complex manner. However, one simple rule always applies: If a hole is not made larger by ballizing there will be no improvements. Conversely, distortion, cracking, and other detrimental effects usually occur if the hole diameter is enlarged too much.

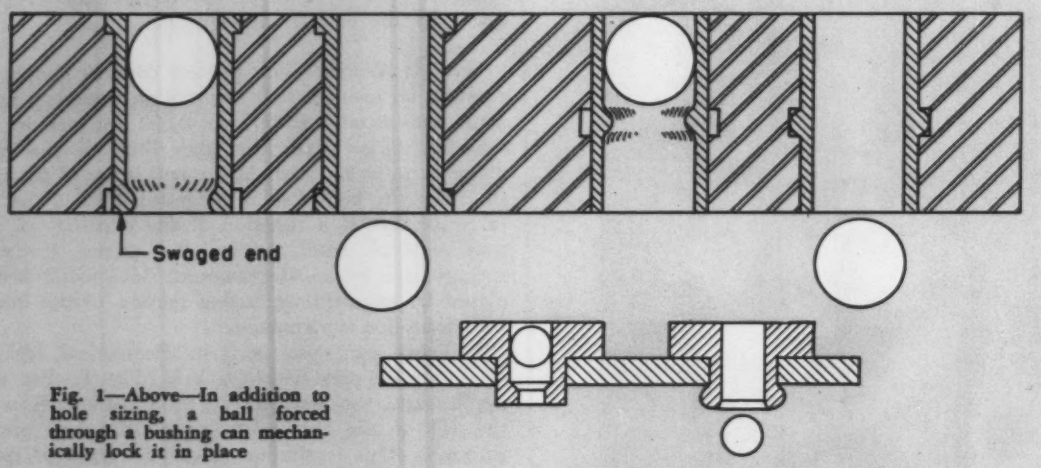
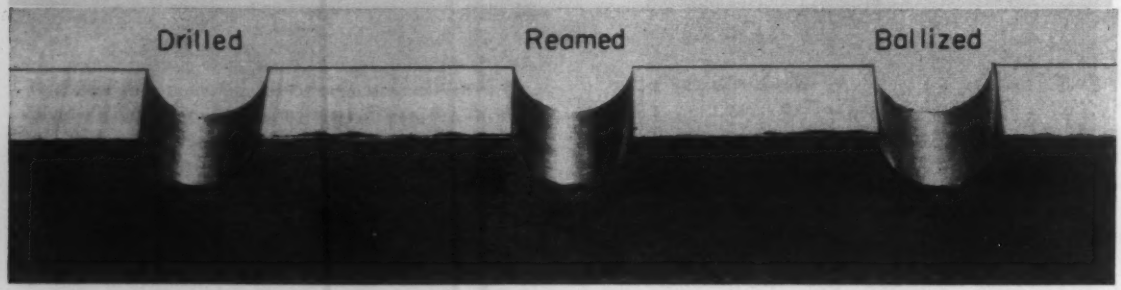


Fig. 1—Above—In addition to hole sizing, a ball forced through a bushing can mechanically lock it in place

Fig. 2—Holes in three stages of process—drilled, reamed, and ballized. Drill was 0.484 in. diam, 220-240 microinch rms finish. Ream was 0.498 in. diam, 82-94 microinch rms finish. Tungsten-carbide ball, 0.5014 in. diam, produced a hole 0.5002 in. diam with a 30-40 microinch rms finish



Improving Surface Finish: Since ballizing causes a reduction of the initial defects in hole size, it also improves the surface finish. However, there are several added variables, such as lay, roughness, waviness, cuts, torn areas, and other surface conditions. Useful reductions in roughness can be obtained by ballizing hardened parts which have been honed or lapped.

If original surface roughness is more than 50 microinches rms, the roughness is almost certain to be superimposed on waviness. After ballizing, the roughness may be reduced by a factor of 3, but all of the waviness will remain. Thus, rough holes when ballized are apt to appear smooth and wavy.

Where Did It Start?

Ballizing progressed through three stages of development. Some possibilities of the method were known and used more than 50 years ago. However, the limited range of precision steel-ball sizes then available kept the discovery from being more than an interesting curiosity.

In almost every instance, ballizing requires a ball of special diameter. Therefore, even when precision balls became plentiful after World War I, the process did not develop rapidly for purely economic reasons. Ball manufacturers did not have facilities for making small lots of special sizes, and users would not gamble with the large lots required to give the method a trial.

The automotive industry was the first to break the economic deadlock. Valve guide bushings and similar small parts were ideally suited to finishing by a ball of suitable size. Fortunately, the large number of parts manufactured justified the minimum quantity for specials.

Over a period of almost 30 years, automotive-parts manufacturing was the major user of this simple but effective means for providing close-tolerance holes. However, a third factor in the progress of ballizing has, for some years, offered many new possibilities. Several radical departures from long-accepted practices in the art of ball manufacturing have made it possible to obtain small lots of any ball size required. Ballizing has now become economically practical, both for prototypes and small-lot production operations.

Good Holes Made Better: Hole making and finishing is usually a series of operations. Some means, such as drilling, is required to create an initial opening. This opening is generally followed by at least one or more stages of refinement. Reaming, boring, broaching, grinding, honing, and lapping are well-known hole finishing methods used for additional refinement.

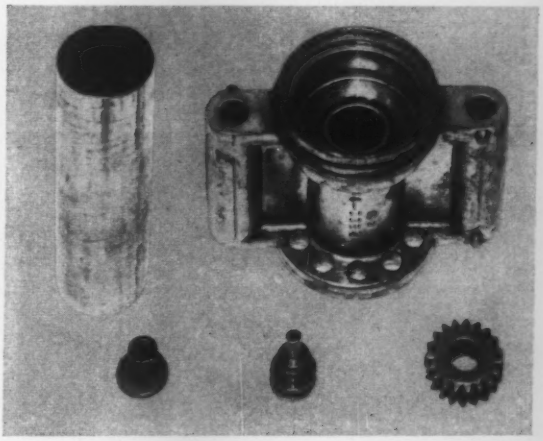
Since a series of preparatory operations must precede ballizing, results obtained will depend on these earlier operations. In any series of operations, ballizing must be the final one. If a ballized hole were subsequently reamed, the benefits of ballizing would reside in the reamer chips.

Ballizing can be followed by heat treating, in the same way that ground parts can be heat treated. However, the good effects will be degraded in either case. Heat treated parts can be ballized (with a tungsten-carbide ball) but the benefits will be practically nil in parts harder than Rockwell C 42. Below this recommended maximum, the results will be in inverse proportion to hardness.

Design Considerations: Ballizing is being used successfully for holes ranging from 0.020 to 5 in. diam, with hole diameters between 1/16 and 1 in. giving optimum results, Fig. 3. Generally, the hole length should be between 0.05 and 10 times the hole diameter. Uniformity of wall thickness can be an important factor, and difficulty may be expected if the wall thickness is less than 0.1 the hole diameter. Additionally, the wall thickness from one side of the hole to the other should not vary more than 2 to 1, nor should it vary more than 3 to 1 from opening to exit of hole.

The part material should be ductile and homogeneous—with a minimum of porosity and sponginess. Materials with hard spots, as in castings, are frequently not suitable for ballizing (although there are examples of cast-iron parts being successfully

Fig. 3—Ballizing can be used to finish holes in a wide range of parts, including tubing, machined parts, powdered-metal parts, and die castings



ballized). Equally important is the need for minimum variance in hardness from piece to piece. Materials above a hardness of Rockwell C 40-45 may not improve much in surface finish. With the exception of cast iron and other similar materials, the expected surface roughness improvement is 50 per cent or better.

Most metals can be ballized, but some lend themselves more readily than others. For optimum results, the following materials and machining methods, in their respective order, are ideally suited for ballizing:

Materials

1. Sintered iron, sintered brass, and other powdered materials
2. Aluminum, brass, and bronze
3. Mild steel, screw stock
4. High-carbon and alloy steel
5. Stainless steel and other nickel-bearing alloys

Machining Methods

1. Tungsten-carbide or diamond bored
2. Reamed
3. Die cast, drawn, or extruded
4. Broached
5. Drilled

Pressure required for pushing a ball through a given part varies with the hole length and size, compatibility of ball and part material, interference fit, elastic properties of the material, and lubricant used. With holes under 3 in. diam, the maximum pressure required should not exceed 2 tons.

In some instances, plating before ballizing should be specified. This provides lubrication for the ball and a finer finish of the hole due to filling of the minute scratches and tears from a drill or reamer operation. Any pores in the plating are closed by the ballizing operation. When plating is not practical, waxes and sulfurized oils can usually be used satisfactorily.

Suggested Uses for Ballizing: There are three general purposes for ballizing, any one of which may be of sufficient value to warrant specifying the process.

SUBSTITUTE FOR OTHER OPERATIONS: When a conventional process (grinding, for example) produces a quality in excess of functional requirements of the part, ballizing may suffice—and be much more economical. Ballizing may be used when conventional methods are inferior. Some metals, tantalum for example, are difficult to finish by any other means. Cost-reduction requirements may suggest ballizing to replace another hole-finishing process since costs can be reduced at a minimum sacrifice of quality.

IMPROVEMENT ON OTHER OPERATIONS: To meet specifications, or for competitive reasons, a minor improvement in hole uniformity, surface finish, or wear resistance may be required to make parts acceptable. Adding ballizing will be indicated in such cases. Cost of both equipment and direct labor are highly in favor of ballizing. Scrap losses caused by the ballizing operation are substantially zero.

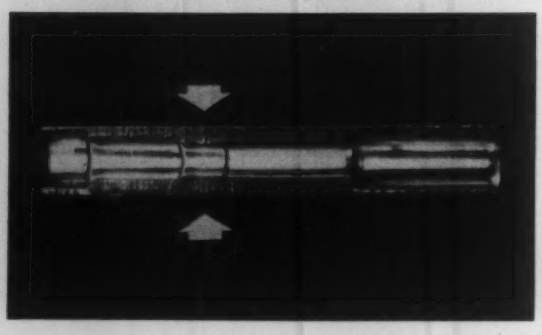
SECURE PROPERTIES NOT OTHERWISE AVAILABLE: Ballizing can perform operations which cannot be done as well by other means, such as

1. Staking parts, bushings, or assemblies.
2. Smoothing internal surfaces.
3. Removing burrs.
4. Correcting warpage or distortion of copper-brazed parts.
5. Removing dents in tubing.
6. Stretching thin-wall tubing to offset mill variations.
7. Equalizing grinding-stock for carburized parts.

Some times, ballizing can accomplish operations impossible to do by other means:

1. Internal work-hardening, such as for rifle barrels.
2. Smoothing of honed or lapped surfaces.
3. Equalizing of residual-stress differences.
4. Producing graded sizes for selective assembly by use of graded ball diameters.
5. Improving ease of assembly. Bushings can be enlarged in the hole, rather than pressing in.
6. Securing better press-fit conditions by smoothing bore.
7. Prestressing of bores.
8. Providing densified layer for powdered-metal parts.
9. Improving surface finish after plating and other surface treatments.
10. Finishing hole deep within parts where required tool overhang prevents securing desired precision by other processes, Fig. 4.

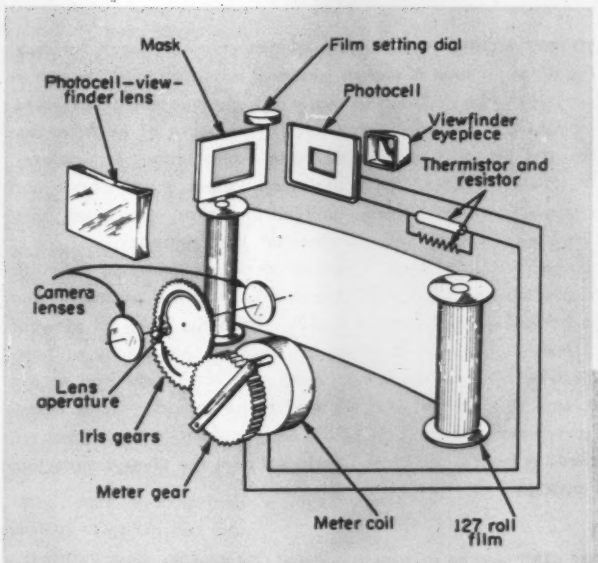
Fig. 4—Ballizing can be used to achieve fine tolerances and finishes on holes that are difficult to reach with other processes



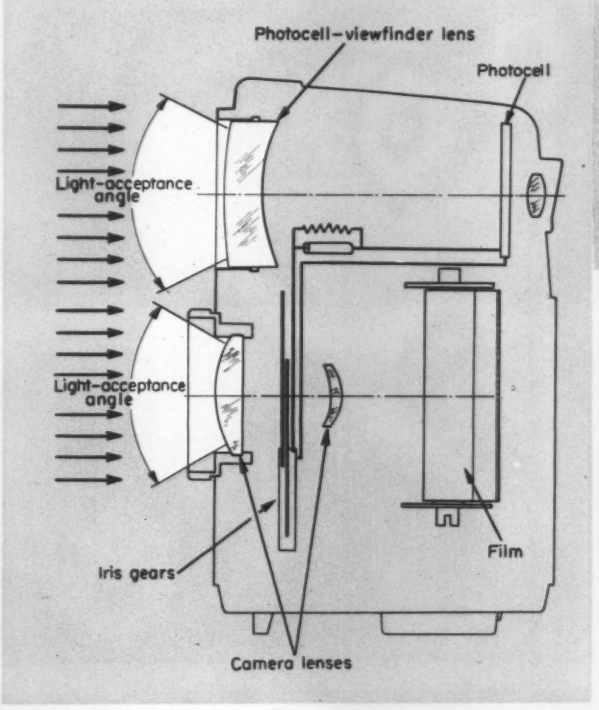
Limitations of Ballizing: Some holes cannot be finished by ballizing—although the process is well worth considering in most cases. Bores that are partially interrupted or have undercuts may be impractical to ballize since uniform sizing is generally not possible wherever the ball is not entirely confined by the ID. Parts with cross holes of diameters less than 25 per cent of the ball diameter can be ballized if the axis of the cross holes runs through the axis of the ballized hole.

The ball tends to follow the path of the hole and will not straighten curved or crooked holes. However, it will improve elliptical, tapered, or out-of-round holes to some degree, although it will never bring them to complete perfection.

Photocell Adjusts Lens Opening



CONTINUOUS ADJUSTMENT of lens aperture to changing light conditions is feature of new medium-priced still camera. Known as the Bell & Howell Infallible, the camera uses two iris gears designed with overlapping, variable-width slots to change aperture size. The iris gears are driven by a gear mounted on a meter coil, which receives current from a photocell. Angle of rotation of the meter coil depends on the amount of current it receives from the photocell, which is controlled by light intensity.

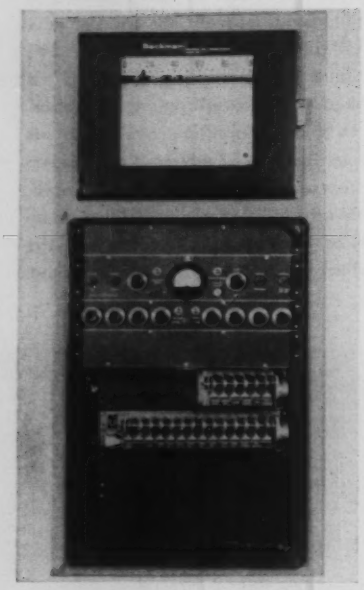


ANGLES OF LIGHT ACCEPTANCE of the camera lens and the combination viewfinder-photocell lens are identical. The photocell is located in the same plane as the film. Since the photocell is mounted at the rear of the camera and inside the viewfinder, only the light coming directly from the subject being photographed strikes the photocell.

To adjust photocell output to correspond to slow or fast films, a mask is positioned over the photocell with a film-setting dial.

A thermistor and resistor compensate for variations in ambient temperatures.

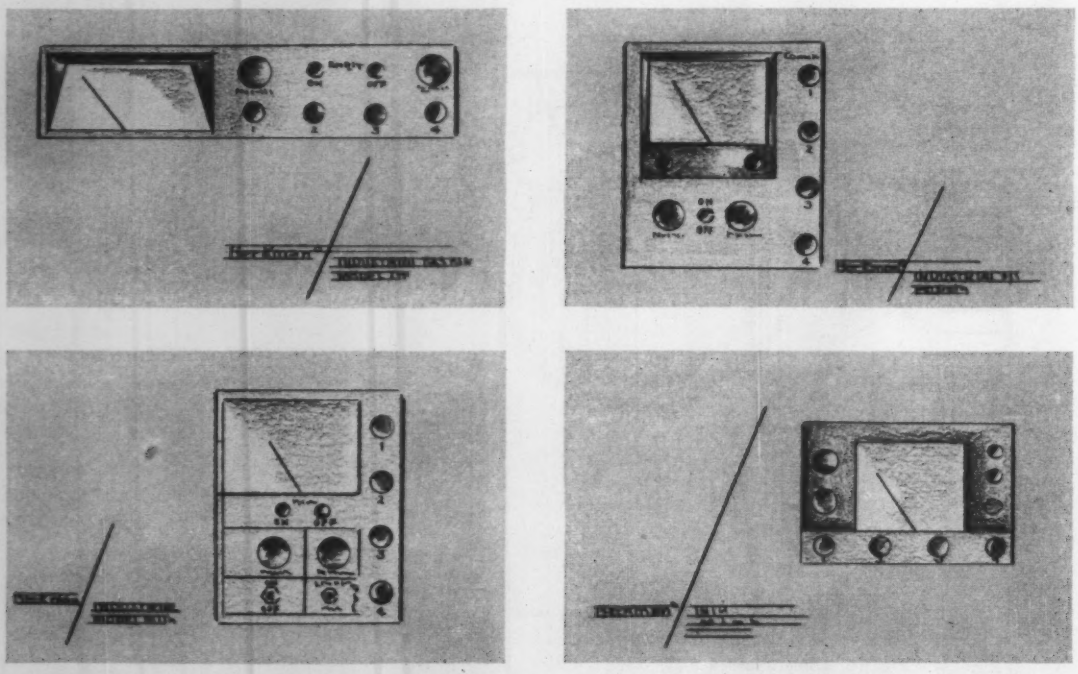
Indicators and Controls Grouped



WORKING PROTOTYPE MODEL of an industrial gas chromatograph for analyzing industrial process streams is shown before it was designed for manufacture and sale. Developed to detect as many as eight components in gases, the instrument measures and records on charts the amount of each component. The complete instrument consists of three major units: 1. Analyzer. 2. Controller. 3. Chart recorder. In actual installations the analyzer and controller are separated, and the recorder is fixed in design. Therefore, functional and appearance redesign was focused on the controller.

As reported by David J. Malk, product design consultant, Scientific and Process Instruments Div., Beckman Instruments Inc., the controller and its control panel had to be designed primarily "from the point of view of the operator." Design objectives centered on ease of use, clarity of function, and indication of proper operation. Also, the instrument had to use a standard case, and the manual controls had to be locked. These objectives had to be correlated with the practicality of manufacture, costs involved, and proper functioning from a technical standpoint plus the always-important aspect of sales appeal.

INITIAL REDESIGN STEP was to itemize functions and frequency of use of the indicator lights, switches, variable controls, timers, and meter on prototype

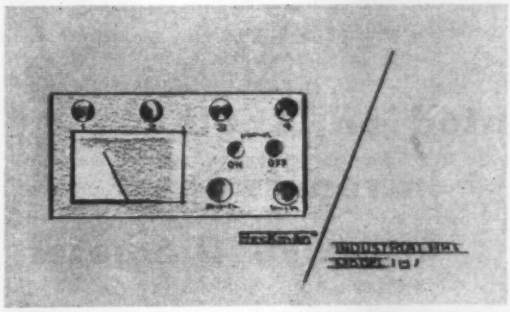


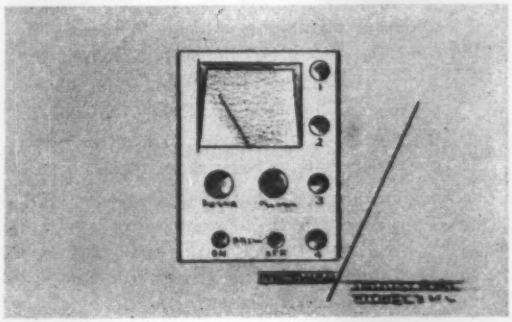
By Function into Four Areas

model. These data were thoroughly analyzed. Changes were made in number of lights and switches to meet functional requirements better.

Several sketches of the control panel were made and reviewed by the engineering and sales departments.

Pasteboard models of the more promising panel designs were produced. These models, built to exact scale, were reviewed again by engineering, sales, and management. Several suggestions were submitted after making a final choice.





FINAL PANEL DESIGN is divided into four functional areas by two white lines—one vertical and one horizontal. All items above the center horizontal line are for visual reading, including an ammeter and eight indicator lights which are visible through the closed door.

All items below the center horizontal line are manual controls, which are set when the instrument goes on stream and are seldom reset. The panel door prevents accidental resetting.

Controlling and indicating components to the left of the vertical white line pertain to the repetitive function of the instrument. All items to the right relate more directly to plant-stream control, with settings dependent upon plant-stream composition and readout requirements.

Pushbuttons Permit High-Speed "Dialing"

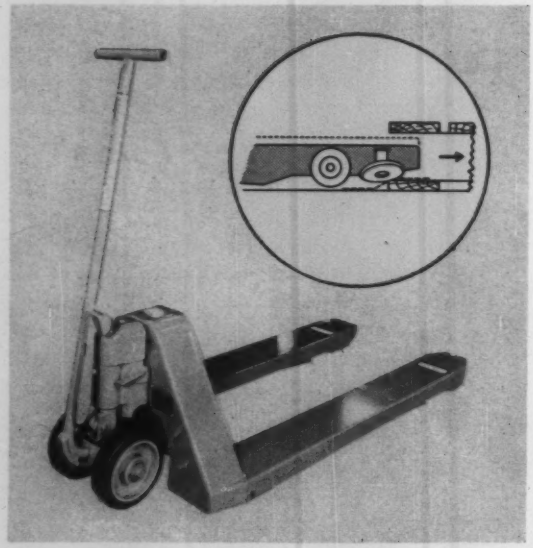
"DIALING" TIME is reduced nearly 50 per cent, on the average, with a telephone developed by Bell Telephone Laboratories Inc. Time savings accrue both in "dialing" the number and selecting the next number in comparison to the dial-type instrument.

In this design, the pushbuttons send multifrequency tones instead of the usual dc pulses to convey the number called to the central office.

A tone ringer, instead of bell, summons the party with a more pleasant and seemingly softer sound; actually the sound can be heard farther from the called telephone. Transistorized circuits are used for both speech transmission and tone ringing.

Another variation under development is a so-called "repertory dialer." Circuitry is built into the telephone instrument to record and remember 50 frequently called telephone numbers. A number is selected by moving an index to the name of the desired party and is transmitted by pressing a single "call" button.

Wheel Mounted on Angle Increases Its Effective Diameter



EASIER ENTRY of the fork into the pallet is a design advantage claimed in a new lift truck developed by the Barrett-Cravens Co. A disc replaces the conventional roller wheels on the end of the truck fork. The axle of the disc is set at an angle to give the effect of adding 3 in. to roller diameter.

The Personal Side of Engineering

By EDWIN C. NEVIS Personnel Research and Development Corp., Cleveland, Ohio

Increasing Job Satisfaction

IN THE past few years much attention has centered on obtaining maximum productivity from engineers. Management, quite concerned over practical demands for increased technological effectiveness, has devoted much time and attention to the question. Many programs and procedures have been adopted in an attempt to provide more satisfaction for engineers, increase morale and, in the process, to achieve higher productivity. Participation in technical societies, higher wages, broader fringe benefits, and the like have all been utilized as a means of making the engineer's job more attractive.

Certainly these job benefits are essential aspects of desirable working conditions. In many cases they represent areas where engineers were somewhat poorly treated. However, one must ask whether these benefits are likely to achieve long-term objectives of the engineer or management, even though they may fit the needs and desires of engineers. An examination of some of the important needs of engineers and the meaning of work for this occupational group suggests that this might not always be the case.

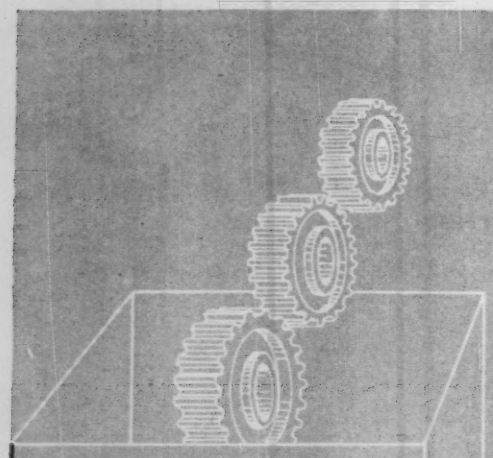
As indicated in earlier articles (MACHINE DESIGN, May 2 and 30, 1957), engineers as a group tend to be highly work and task-involved, and their major satisfactions derive from accomplishment in dealing with technical problems. Their logical, relatively perfectionistic approach to work suggests that the opportunity to deal with interesting, challenging work and recognition for accomplishments in solving problems would be of greater meaning to them than any other kind of reward. Recognition does not necessarily mean monetary or status rewards. Rather, it means attention to and open identification of the importance of work being performed by the engineering group and the providing of even more challenging opportunities and interesting assignments for engineers who have demonstrated ability to handle greater responsibility.

A recent study, soon to be published by Frederick Herzberg of Western Reserve University, substantiates the fact that fringe benefits and monetary rewards may not be as important in the attainment of high morale as are the more potent motivating factors of opportunity to do interesting work and recognition of accomplishments.

In this study the job attitudes of a group of management people, primarily engineers, were studied. It was found that where low morale existed, there was a tendency for people to be unhappy about their wages, the way they were treated by their supervisors, their fringe benefit programs and the like.

On the other hand, the mere prevalence of good working conditions was not found to be sufficient to bring about a high level of morale. Something else was needed and present among work groups of high morale. In this study, the individuals who were most happy and satisfied in their work felt that they had more opportunity to try their hand at interesting and challenging work. Their importance to the organization was more openly recognized.

Though it is difficult to relate high morale to increased productivity, the importance of these findings is the implication that good human relations, a high wage scale, and good fringe benefits are not enough to insure maximum performance from engineers, even though they are necessary and important aspects of an engineering personnel program. By providing a stimulating work environment, management can add just the impetus needed to carry the engineer beyond the point of merely being not dissatisfied with his work setting and create an active attitude on the positive side of the ledger.



Which combination of high-strength steel and heat treatment for

HIGH-CAPACITY

- **Gear steels**
- **Hardening procedures**
- **Dimensional stability**
- **Processing conditions**

TO function properly, a high-strength, precision steel gear must have adequate load-carrying capacity, resistance to wear and pitting, resistance to fatigue, adequate corrosion resistance for its environment, and capability of operating within the designated temperature range. However, it is obvious that a single material may not satisfy all of these requirements for a variety of applications.

Before selecting a gear steel (and its subsequent processing method), required gear qualities must first be determined. These qualities should be described quantitatively wherever possible so that a selection can be made based on specific engineering data. For example, if the bending load to be imposed on the tooth of a gear is known, it is possible to determine if the combination of a given steel and processing method will prevent fatigue failure.

The designer has several types of gear steel from which to choose. Each steel has its own unique advantages and disadvantages as well as its own peculiar processing considerations. This article covers metallurgical factors which influence design and manufacture of high-strength precision gears.

High-Strength Steels

Four types of steel may be considered for high-strength gears—low-alloy steel, carburizing steel, nitriding steel, and stainless steel. Fig. 1 shows how a medium-carbon steel which contains no alloying elements must be modified to meet the chemical requirements of various steel types.

For low-alloy steels it is necessary merely to add suitable alloying elements such as chromium, nickel, vanadium, and molybdenum to increase hardenability of the steel. Carburizing steels are similarly alloyed, but they also require a reduction in carbon content for the purpose of providing a tougher core subsequent to heat treatment. Nitriding steels are similar to many low-alloy steels in chemical composition with the addition of approximately 1 per cent aluminum for forming hard nitrides. Hardenable stainless steels are basically high-chromium steels (12 to 17 per cent) to which other alloying elements are added for special reasons. Carbon content may range from about 0.1 to more than 1 per cent.

Low-Alloy Steels: These steels are suitable for gears which require medium to high wear resistance and high load-carrying capacity. Low-alloy steels are generally used for through-hardening applications. However, induction hardening, flame hardening, and even nitriding are additional hardening techniques frequently employed.

Through-hardening of low-alloy steels represents the least expensive method for producing high-strength gears. When a steel with sufficient hard-

GEARS

By ROBERT Y. SCAPPLE
Hughes Aircraft Co.
Culver City, Calif.

enability is used, core strength in excess of that of carburized or nitrided gears may be achieved. However, through-hardened, low-alloy steel gears are not as resistant to surface wear or fatigue as carburized or nitrided gears.

Carburizing Steels: For gears which will be subject to heavy-duty service, carburizing steels are recommended. Resultant high surface hardness and favorable residual compressive stresses provide a high resistance to wear, pitting, and fatigue. For heavy-duty service, the surfaces are sufficiently hard to resist wear and of sufficient depth to prevent crushing. The core also has enough strength to support the case load. Core strength properties are dependent upon the particular steel used and the heat-treatment process employed.

Nitriding Steels: For gear applications where a hard, wear-resistant case, good fatigue strength, and low notch sensitivity are desired, nitriding steels are used. Nitrided gears may also be used for elevated temperature applications since the hardness of a nitrided case does not diminish at temperatures to 800 F. Nitrided gears should be considered when sections too thin for carburizing must be used.

Because of the relatively thin nitrided case, as compared to a carburized case, nitrided gear surfaces are more susceptible to crushing where overloads are encountered.

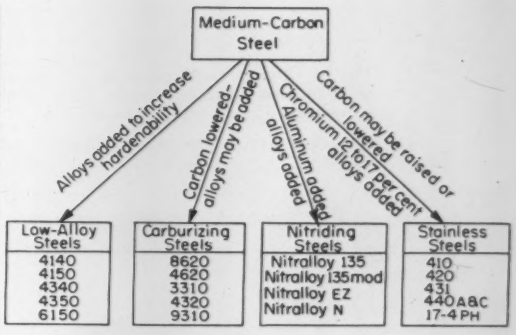


Fig. 1—Alloy steels suitable for high-strength gears

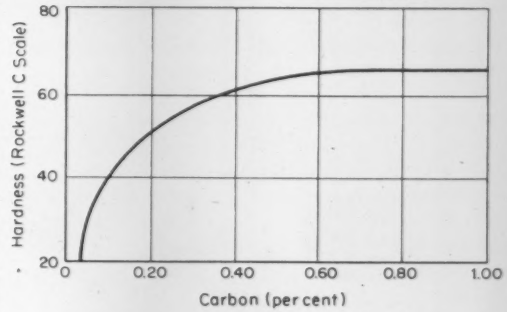


Fig. 2—Maximum hardness attainable in plain-carbon or low-alloy steel

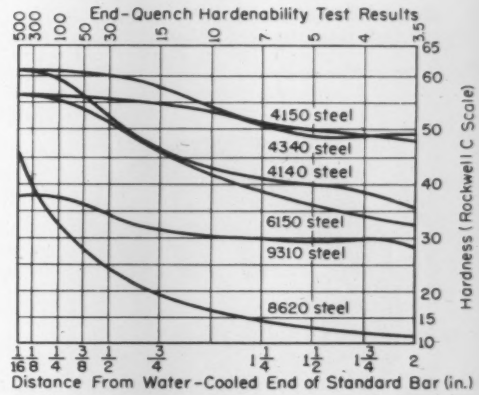


Fig. 3 — Typical as-quenched hardenability. Steels of high hardenability tend to retain quenched-end hardness for a greater depth or distance than do steels of low hardenability

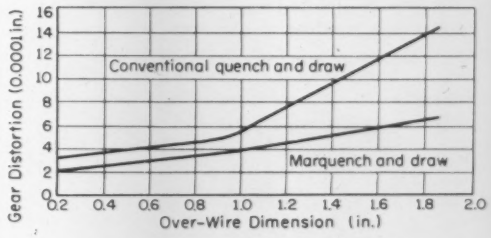


Fig. 4—Effect of gear size and heat treatment on distortion of AISI 4340 steel gears. Hardness obtained by marquenching is approximately the same as that obtained by conventional quenching

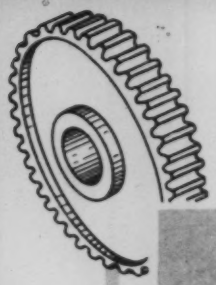
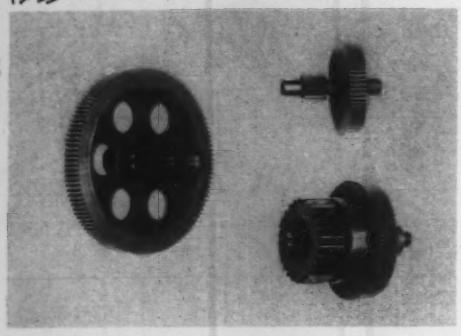


Fig. 5—Design configuration of gears used in heat treatment study. Hardness of quenched gears was Rockwell C 53



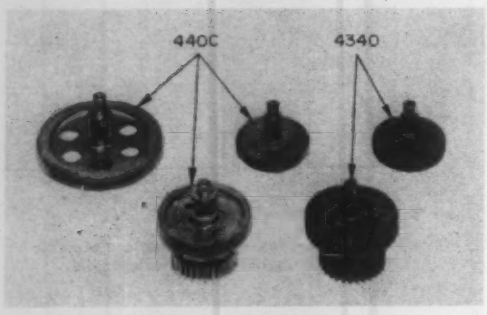


Fig. 6—Corrosion resistance of Types 440 C and 4340 gears after 250-hr humidity test. Type 440 C is relatively low in ductility and tends to be notch-sensitive

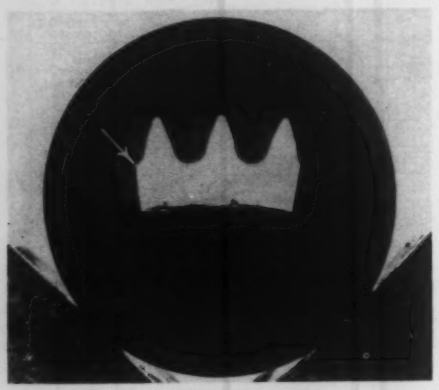


Fig. 7—Carburized case removed by excessive grinding of root area

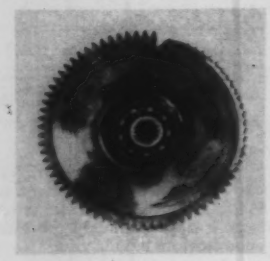


Fig. 8 — Service failure resulting from excessive grinding of root area

Stainless Steels: Where resistance to corrosion is a major requirement, stainless-steel gears are primarily used. Additional advantages of these gears are good mechanical properties and resistance to softening at elevated temperatures. Stainless-steel gears are generally used in the through-hardened condition, but induction hardening and nitriding may be employed. However, when stainless-steel gears are nitrided, there is a substantial loss in corrosion resistance.

▶ Heat Treating

Heat treating is perhaps the most important process in gear manufacturing because of its influence on properties and performance. In its broadest sense, heat treating includes all processes involving a time-temperature cycle. Of primary concern in gear manufacturing are through-hardening, carburizing, nitriding, induction hardening, and flame hardening. Stress relieving and annealing treatments are also important when used as supplementary treatments for minimizing distortion.

Through-Hardening: This process produces a uniformly hard and strong gear which shows little difference between mechanical properties of core and surface. Through-hardening has the advantage of being a simple, economical process which provides high-strength properties throughout the entire gear section. The simplest form of through-hardening involves heating the entire gear within the austenitic temperature range, quenching in a suitable medium (water, oil, or atmosphere depending on hardenability of the steel), and tempering to required hardness.

Since hardness is generally the criterion to which gear designers work, factors that determine hardness of a steel gear should be examined. Fig. 2 shows the relationship between maximum obtainable hardness and percentage of carbon for plain-carbon and low-alloy steels. It is apparent that carbon content alone determines maximum hardness attainable. For example, AISI steels 1040, 2340, 3140, 4140, 4340, and 4640 can be hardened to the same maximum hardness since all contain 40 points of carbon.

The ease with which these steels may be hardened and the depth to which they can be hardened depends on alloy content. Fig. 3 shows hardenability curves for several steels. These curves are obtained by making a hardness traverse along the length of a standard test specimen which has been hardened by means of a water quench at one end of the bar. Steels which have high hardenability tend to retain their "quenched end" hardness for a greater depth or distance along the specimen than steels of low hardenability.

To summarize, carbon content determines maximum hardness attainable, while alloy content is important in determining hardenability or depth of hardness obtainable. Hardness and hardenability are separate and distinct qualities; that is, a steel

may have high hardness and low hardenability or low hardness and high hardenability.

To keep distortion to a minimum, it is frequently necessary to use a modified through-hardening procedure such as marquenching. This process is an interrupted-quench type heat treatment which not only minimizes distortion but also reduces internal strains. Marquenching is accomplished by quenching the gear in a suitable medium (usually a hot salt bath) to 400 to 600 F, the temperature at which the gear begins to harden. The gear is held at this temperature for a period of time (to 10 min depending on the steel used), air cooled to room temperature, and tempered to the appropriate hardness.

Marquenching may be used only for steels that have sufficient hardenability. Hardness obtained by marquenching is approximately the same as that obtained by conventional quenching. Advantages of marquenching AISI 4340 steel gears are shown in Fig. 4. Here, the marquenched gears were austenitized at 1475 F, quenched in salt at 550 F, and, after 20 seconds, removed from the salt and air cooled. They were then tempered at 400 F. Gear designs used in this investigation are shown in Fig. 5. Both the marquenched and conventionally quenched gears showed a hardness of Rockwell C 53 after a 400 F temper.

Steels which have a very high hardenability may be quenched from their hardening temperature by simply cooling in air or under a controlled furnace atmosphere. Advantages of air or atmosphere quenching are lower quenching stresses and lower distortion. Type 440 stainless steels, for example, may be hardened in this manner. Their cooling rate can be so slow that 5 min may be allowed for them to cool from the hardening temperature (1700 to 1900 F) to 1250 F. Below 1250 F they may be cooled at a still slower rate. Distortion (change in runout as a result of heat treatment) of Type 440 C stainless-steel gears when hardened as outlined above, is considerably less than for marquenched AISI 4340 gears. Stainless-steel gears of the same design as those of Fig. 5 showed an average distortion of 0.0001 to 0.0003 in. and a hardness of Rockwell C 54 to 55 after a 600 F draw.

Type 440 stainless-steel gears find application where a high degree of corrosion resistance is required. Their corrosion resistance is considerably better than that of AISI 4340 gears, Fig. 6. However, Types 440 A and, particularly, 440 C are relatively low in ductility and tend to be notch-sensitive which should be considered in design. At tensile-strength values of 270,000 psi, 440 A has an elongation value of about 5 per cent while that of 440 C is about 1 per cent.

Carburizing: This process produces a composite gear which has core properties different from those of the surface or case. During carburizing, a low-carbon steel is subjected to a carbonaceous environment at temperatures from 1650 to 1750 F. Carbon from the environment diffuses into the steel at a rate of from 0.004 to about 0.008 in. per hr depending on the particular conditions. As a result, the carburized case has the capability of achieving a higher hardness level than the core, Fig. 2. Case-hardness values after heat treatment range from Rockwell C 62 to 64. Hardness of the core depends upon hardenability of the steel and on its carbon content. Typical core hardness values for alloy steels range from Rockwell C 20 to 40.

Numerous hardening procedures have been used for carburized gears. However, where low distortion is important, two procedures should be considered: Direct quenching from the carburizing furnace, and marquenching. In each case, metallurgical principles that apply are the same as those covered under Through-Hardening. The difference is simply that the gear will contain a duplex structure of a high-carbon case and a low-carbon core.

As a general rule, to provide sufficient load-carrying capacity, the carburized case depth should be about one-sixth the tooth thickness at the pitch

Fig. 9—Depth hardness of Nitralloy 135 modified (Floe process)

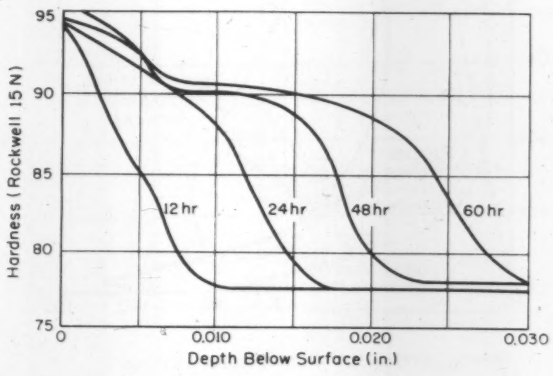
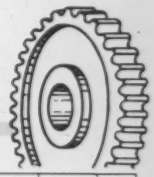
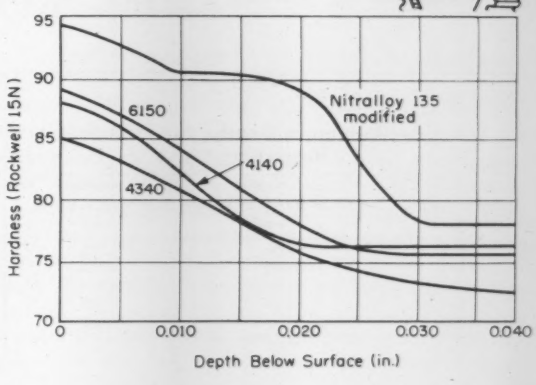


Fig. 10—Depth hardness of nitrided AISI steels and Nitralloy 135 modified





line with a maximum case depth of about 0.070 in. It is important to guard against excessive removal of the carburized case by subsequent grinding operations. Fig. 7 shows a condition of excessive grinding, and Fig. 8 shows the resulting failure of the gear in service. In this instance, benefits derived from the carburized case were lost by removal of the case at the tooth root. When it is desirable to carburize only certain areas of a gear, remaining areas may be masked by copper plating to a thickness of 0.0003 in. or greater.

Nitriding: This process for case hardening steel parts requires heating them in an atmosphere of partially dissociated ammonia gas at a relatively low temperature (950 to 1050 F), and does not require quenching to achieve hardness. Because of the low processing temperature, parts are through-hardened prior to nitriding with no loss in core properties subsequent to the nitriding operation. Nitrided parts have an exceptionally high case hardness (Rockwell C 65 and higher) which is retained even after heating to 800 F.

Hardness of the case is attributed to formation of various alloy nitrides. Since nitriding is a diffusion phenomenon, nitride concentration at the surface is greater than at any point beneath the surface. Because of this high concentration, a rather brittle white layer consisting of iron nitrides and alloy nitrides forms at the surface. Depth of the white layer depends on many factors. Present-day methods utilizing the Floe process make it possible to reduce the thickness of this layer to less than 0.0005 in. as compared to the 0.002 in. of older methods. With the Floe process, the white layer need not be removed whereas grinding or lapping is necessary with older methods. Because of this brittle white layer formation, sharp corners should be avoided. With sharp corners, the white layer (thicker at corners than at adjacent flat surfaces) will chip or spall if subjected to light loads.

The best nitrided case is that produced with a standard nitriding steel such as Nitralloy 135 modified or Nitralloy N. However, many other steels can be nitrided to good advantage. For example, nitriding AISI 4140 gears as a salvage measure proved to be the solution to a gear problem when it was found that completely finished gears were actually galling during factory testing. Effect of nitriding various alloy steels other than those specifically designed for nitriding is shown in Fig. 10.

Table 1—Minimum Depths for Induction Hardening

Induction Frequency (cps)	Approximate Minimum-Hardness Depth (in.)	Theoretical Penetration-Depth (in.)
3,000	0.060	0.035
9,600	0.040	0.020
120,000	0.030	0.006
500,000	0.020	0.003
1,000,000	0.010	0.002

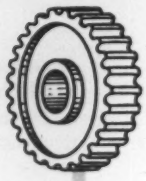


Fig. 11—Effect of frequency on depth of hardening. Distortion in induction-hardened gears can be kept to a minimum if heating is fast and uniform

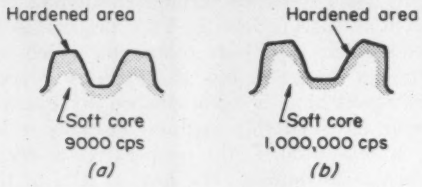


Fig. 12—Residual stress in carburized and nitrided gear teeth. Both processes are usually specified to provide hardness and wear resistance

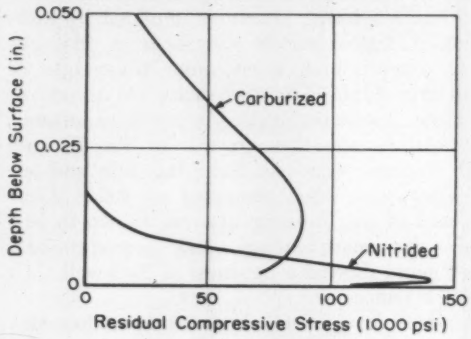


Fig. 13—Estimated relative fatigue strength of nitrided and nonnitrided rotating-beam specimens. Presence of a ground notch did not appreciably affect endurance strength

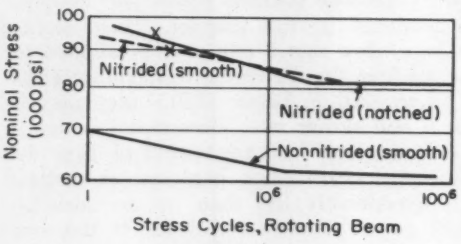
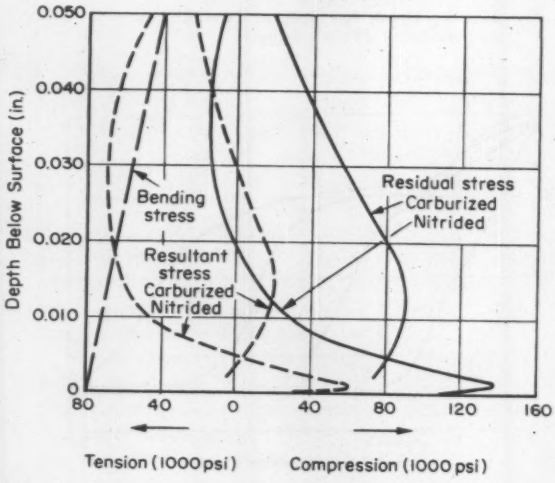


Fig. 14—Effect of a superimposed bending load on a carburized and nitrided case. Gears subjected to heavy duty are generally carburized rather than nitrided



Core tensile strengths achieved in nitrided gears range to 190,000 psi for Nitralloy N. Nitralloy 135 Modified can be heat treated to core tensile strengths to 180,000 psi. Nitralloy N, however, has the advantage in that it can be machined in the soft condition and the core hardened by a precipitation mechanism during subsequent nitriding.

If parts are of a uniform section and have been treated so that no internal stresses are present, nitriding produces no distortion. However, because of the compressive stress inherent in a nitrided case, some distortion may occur in other instances. Fortunately, this distortion is exceptionally uniform from part to part and may be compensated for somewhat in final design. Since nitriding involves a volumetric increase of the case due to formation of nitrides, it is only natural that some growth will occur which must also be compensated for. Round bars, for example, grow approximately 0.0015 in. on the diameter.

Protection of certain areas from nitriding may be accomplished by a tin plate 0.0003 to 0.0005 in. thick. For gears, it is common practice to semi-finish critical surfaces, tin plate, and then finish machine these areas. Thus, only necessary areas will be nitrided, and distortion and growth kept to a minimum.

Induction and Flame Hardening: Both these processes permit heat treatment to be localized within close limits by proper control of heat input and depth of heat penetration. For gear applications, it is common to use a steel having 0.40 per cent carbon or greater. This assures attainment of high surface hardness. The core of the gear may be heat treated prior to surface hardening to provide whatever core properties are desired. Once again, fundamental heat treating principles that apply for through-hardening apply for induction and flame hardening. The only difference is that there are now two heat treatments—one for the core and one for the surface. Use of an alloy steel is of no benefit when considering only required surface hardness. However, when high and uniform-strength core properties are important, these may be easily achieved by choosing an alloy steel of suitable hardenability.

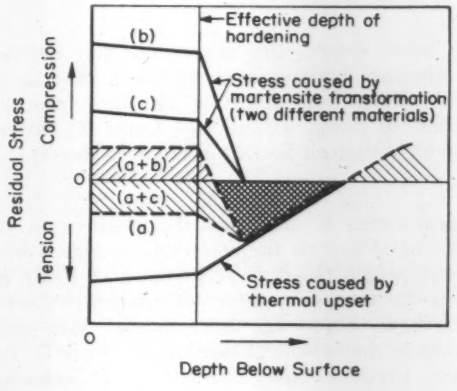
When gears are contour-hardened by induction hardening, it is necessary to choose an appropriate frequency. Table 1 shows effect of frequency on theoretical and practical depth of hardening. It is desirable to harden to a depth equal to one-sixth the tooth width. However, for fine pitch gears this is impractical, and it is customary to harden the complete tooth as well as a portion below the tooth root. Fig. 11 shows effects of frequency on depth of hardening.

Distortion in induction and flame hardened gears can be held very low if heating is fast and uniform. Rotation of the gear during heating and quenching is frequently employed to advantage. As a further refinement, induction hardening of gears may be accomplished under an inert atmosphere to give a bright surface.

Distortion: To some extent, it is possible to generalize ways to minimize gear distortion resulting from manufacturing methods. Following are several factors, in addition to those previously mentioned, which affect gear distortion:

1. Internal stress is the basic cause of all gear distortion and may be caused by essentially every fabrication method employed.
2. Low-hardenability steels distort less for a given quenching method because the central portion of the part does not harden and transform to a larger-volume material.
3. Stress relief of parts is desirable following rough machining. A full anneal accomplishes even better stress relief than a subcritical anneal.
4. Distortion can be minimized to a great extent by using plug or press type quenching fixtures.
5. When heating gears for hardening, distortion is minimized if: The number of times of heating is minimized, hardening temperature and quench rate are kept to a minimum, and if heating and cooling are uniform.

Fig. 15—Residual stress produced by induction or flame hardening. For commonly used gear materials, resultant surface stresses are compressive



Residual Stresses

Residual stresses produced in gear manufacturing may be desirable or detrimental depending on their location and nature. For example, carburizing and nitriding processes produce surface compressive stresses which are beneficial in preventing gear-tooth fatigue failures. On the other hand, grinding operations produce surface tensile stresses which may be very damaging to the teeth. Tensile stresses may be high enough to cause grinding checks or cracks. Gear hardening by means of induction, flame, or conventional through-hardening is not always simple to analyze from a stress standpoint. In general, resultant surface stresses from

these processes are compressive, but it is very possible, depending on the specific material and application, to get surface tensile stresses. The importance of providing compressively stressed gear-teeth surfaces is evident from the fact that fatigue cracks cannot originate or propagate in compressively stressed material.

Carburizing and Nitriding: Although carburizing and nitriding are usually specified to provide hardness and wear resistance, much of the benefit received from these processes may be directly related to the favorable stress pattern achieved. Fig. 12 shows the residual stress pattern of typical nitrided and carburized cases.

The fact that compressive stresses are beneficial is further demonstrated in Fig. 13 which shows that the presence of a ground circumferential notch with

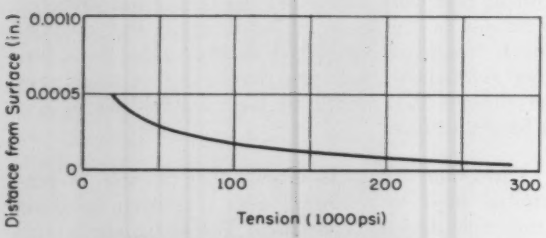


Fig. 16—Residual stress in high-carbon spring steel produced by grinding. Stresses are caused by thermal upsetting

an 0.008-in. root radius and 60-degree angle did not appreciably affect endurance strength of a nitrided specimen. Fatigue failures obtained in these specimens originated in the core of both the nitrided and the nitrided and grooved specimen, and at the surface of the nonnitrided specimen. For groove depths greater than about 70 per cent of the case, failure also occurred at the surface.

Cause of failure originating in the core of nitrided specimens is shown in Fig. 14. When a bending stress is superimposed on the nitrided residual stress, the resultant stress shows a tensile maximum at some point below the surface. Therefore, failure of a fatigue nature is initiated and progresses from this point. A carburized case, however, because of its greater practical depth, is not as subject to this occurrence. For this reason, very heavy duty gears are generally carburized in preference to nitriding.

Induction or Flame Hardening: When studying the effect of induction or flame hardening on residual stresses, consider two mechanisms: Thermal upsetting of the heated surface, and the metallurgical transformation which takes place when steel is hardened. The thermal upsetting mechanism results from the heated surface layer seeking to expand, but being restrained by the colder and stronger underlying metal, it is upset in compression. Upon cooling, the upset metal becomes residually stressed in tension. The second mechanism, transformation, is an inherent property of all heat-treatable steels. During the quenching or hardening operation, there is a phase change that occurs with a resulting volume increase. The precise increase is dependent on the steel used and the hardening procedure adopted. During the tempering operation following hardening, there is an additional volume change, usually a decrease. The net effect of hardening and tempering is usually, but not always, a volume increase. A volume increase results in residual compressive stresses.

Fig. 15 shows how the combination of thermal upsetting and metallurgical transformation can result in either compressive or tensile surface stresses in flame or induction hardened gears. Generally, for commonly used gear materials, resultant surface stresses are compressive.

Through-Hardening: Internal stresses produced by conventional through-hardening practice are exceedingly difficult to analyze in a rigorous manner. Following is a description of the sequence of events during through-hardening: In quenching, the surface expands due to the change to martensite, but then contracts as it cools. The layer underneath, transforming to martensite, expands and, in turn, exerts pressure on both the skin and core. The core cannot yield to pressure exerted from all sides and so exerts a reactive pressure on the outside layers which puts the outside in tension as it shrinks in cooling. As the core transforms, it expands and puts the outside further into tension. As the whole piece cools and the core shrinks, it may ultimately pull the outside layer into compression.

Grinding: Fig. 16 shows residual stresses produced by grinding. Note that the stress values are high and in tension. The mechanism producing this phenomenon is thermal upsetting which is similar to the upsetting effect produced by flame and induction hardening.

They Say . . .

"In some degree, the impression that engineers and scientists have created monsters they cannot control results from scientific aloofness from participation in public affairs." — Louis R. Howson, *president, American Society of Civil Engineers.*

"Creativeness is the essential ingredient in your work. Out of it come the marvelous machines which give our people the highest standard of living ever enjoyed by man, anywhere, at anytime. Through your efforts, knowledge is translated into usable products to the benefit of mankind."—John T. Rettaliata, *president, Illinois Institute of Technology.*

Mounting and Retaining Printed Circuit Boards

By FRANK WILLIAM WOOD JR. and **THOMAS R. SMITH**

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Vitro Laboratories
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Design Draftsman
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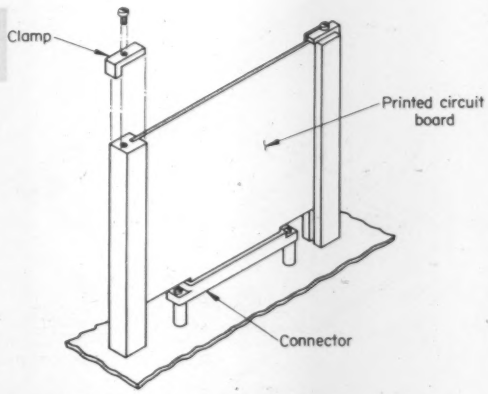
USE of printed circuits has grown to such an extent that a printed-circuit board is thought of as a component much as a potentiometer or a tube. This trend introduces the problem of choosing suitable methods of mounting and retaining printed boards. Choice of particular mountings and retainers is normally decided upon after consideration of the following design factors:

1. Board size
2. Board configuration
3. Type of connector
4. Space available
5. Accessibility desired
6. Vertical or horizontal removal
7. Loose or captive hardware
8. Heat dissipation
9. Type of circuit and relation to other circuits

As a guide to this phase of packaging electronic equipment, here is an assortment of ways to mount printed-circuit boards.

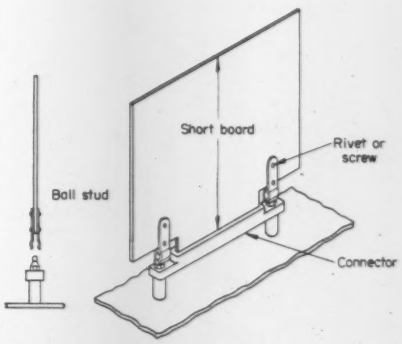
1



Grooved Posts and Angle Clamps

The posts serve as guides as the board is lowered to the connector, then the clamps provide positive retention. Cost of the installation is moderately high.

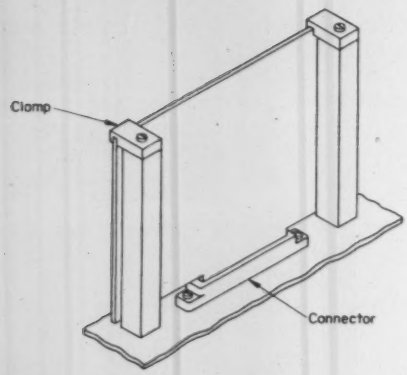
2



Spring Clamp and Ball Stud

Absence of loose hardware is an advantage of this method. Snap-into-place connection (Camlok) enables quick insertion and removal of board. Unless additional support is provided, application is limited to short boards carrying light-weight contents.

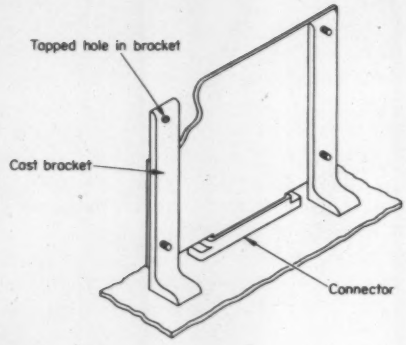
3



Vertical Post and Grooved Clamp

Posts back-stop the board as it is lined up with the connector. Square in section, posts of any length can be cut to correspond to any board size. Cost is moderately high.

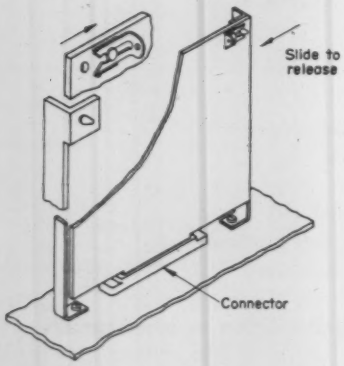
6



Cast Brackets

Good structural support and potential use as a heat dissipator distinguish this arrangement. However, the holding screws are loose hardware, and the brackets are expensive in small quantities.

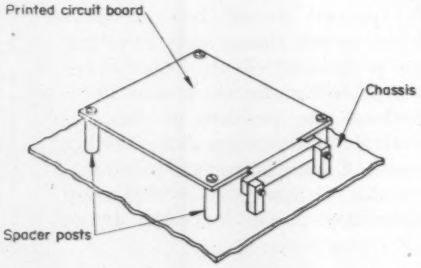
4



Snap Slides

Positive retention of the board on the posts is featured in this arrangement. Other advantages are simple, quick removal and replacement. Hardware is standard, not loose.

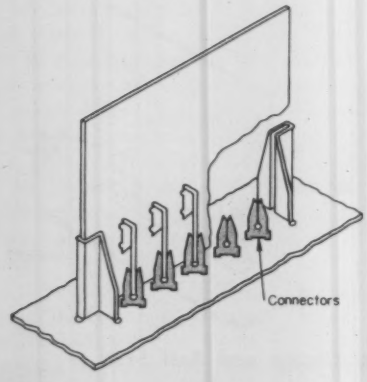
7



Mount on Tapped Spacers

Any size board can be accommodated by this simple, inexpensive mounting. It can be a space-saver on walls and doors of enclosures, but may waste space on a chassis base. Mounting screws are loose hardware.

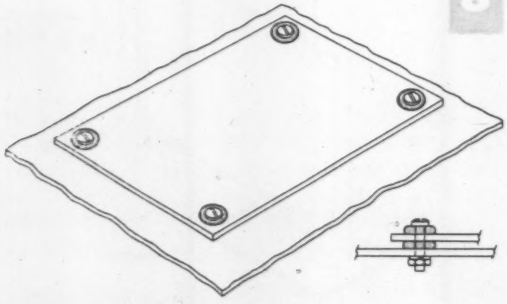
5



Sheet-Metal Support Guides

Although not positively retained in place, boards are quickly removed and replaced, and there is no loose hardware. (Elco).

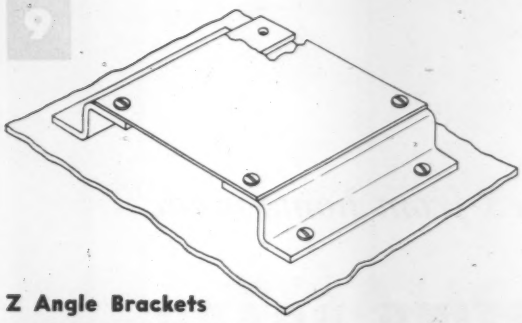
8



Rubber Grommets

Sensitive circuits can be protected from shock with this arrangement. No mounting brackets are required, but the screws, lock washers, and nuts are loose hardware.

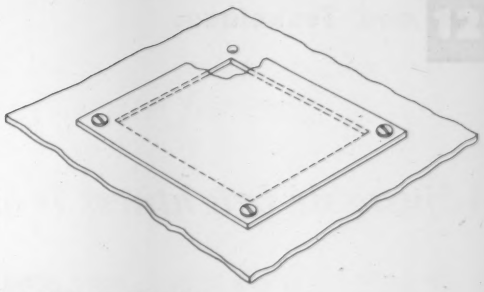
9



Z Angle Brackets

Stock, Z angle strips can be cut to receive any size board. The angles also afford a path for heat dissipation. Mounting screws are loose hardware.

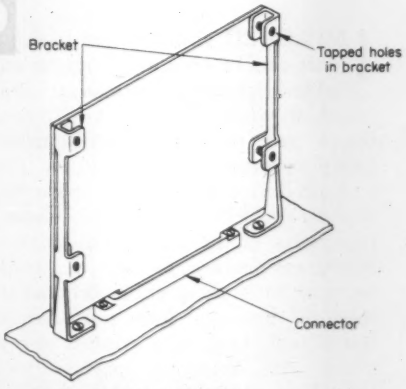
12



Cut-Out in Chassis

No mounting brackets are needed in this installation, and both surfaces of the board are readily accessible. Screws are loose hardware.

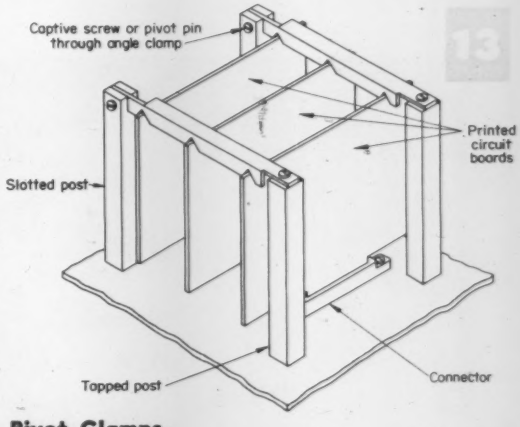
10



Vertical Flanged Bracket

Commercially available in several sizes (Raytheon), these brackets receive two boards back to back. Attaching screws are standard but constitute loose hardware.

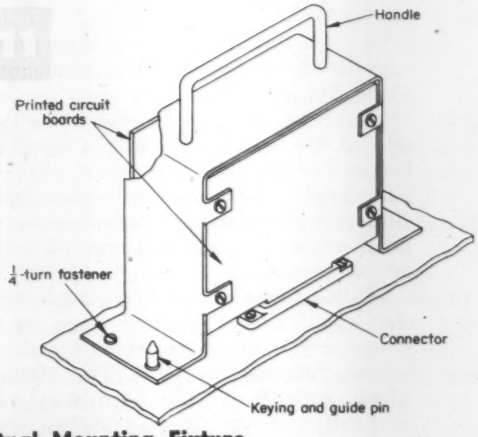
13



Pivot Clamps

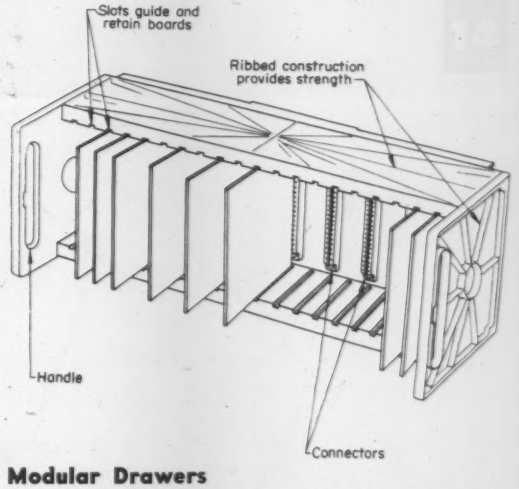
Several boards are retained in place simultaneously in this arrangement. Cost is moderately high. All boards must have the same height.

11



Dual Mounting Fixture

For boards used in pairs, this arrangement provides positive retention in the chassis. A degree of protection is afforded if boards are mounted faces-in. Space consumed and the need for tapped holes in the board may be disadvantages.

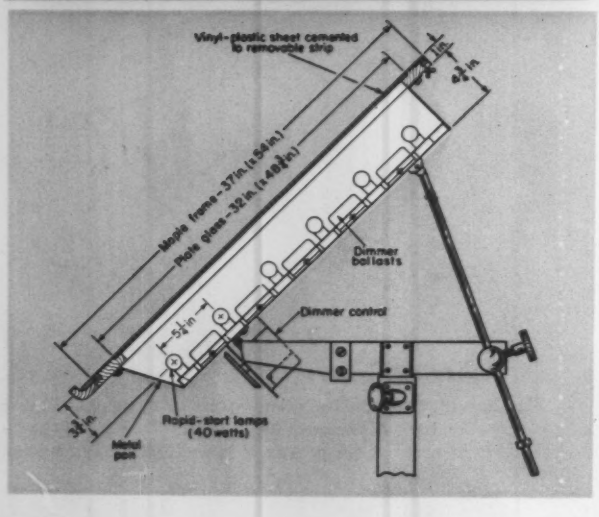


Modular Drawers

Slots in drawer sides guide boards to connectors in the drawer base (Thompson-Ramo-Wooldridge). Drawer itself becomes a component of a multiple-drawer system.

Adjustable brightness is obtained from home-made

LUMINOUS DRAFTING BOARD



IMPROVED visibility and seeing comfort can be obtained from an adjustable-brightness, luminous drafting board, in which standard 4-ft fluorescent lamps are used for transillumination. Lamp brightness is changed by turning a knob on a standard autotransformer dimmer which is mounted under the front edge of the board. The adjustable-brightness feature permits the board to be used for making either original drawings or tracings. The transilluminated board with brightness control also eliminates the annoying shadow problem from T-squares and triangles.

For typical drafting work, the dimmer is set near the low end of its range where it produces a comfortable surface brightness. Panel brightness can be raised for tracing dense blueprints. With this board, general room lighting should be 50 foot-candles.

Uniform surface brightness is obtained with six 40-watt fluorescent lamps mounted on 5¼-in. centers with lamp centers 3¾ in. below the panel surface. The inside of the metal pan, which supports lamps, ballasts, and dimmer, is painted flat white to diffuse and reflect the light efficiently. Fluorescent lamps develop a small amount of heat as compared with incandescent lamps.

White vinyl-plastic cover placed over the ¼-in. clear, tempered plate glass serves several other important functions besides diffusing the light. The plastic, which is 0.007-in. thick, provides both a slightly resilient drawing surface and medium for the point of a compass to grip. Paper masks of various densities can be inserted between the plastic and the glass top for reducing panel brightness around a drawing.—CARL J. ALLEN, *engineer, Lamp Div., General Electric Co., Cleveland, Ohio.*

How to use influence factors to calculate shaft

MISALIGNMENT MOMENTS

By AUGUSTINE J. SCALZO*
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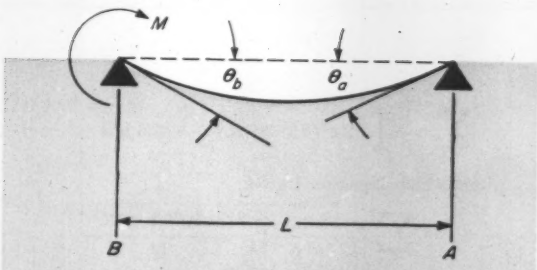

Fig. 1—Simply supported shaft. Slope of elastic curve caused by unit moment is the influence factor

SHAFT stresses and bearing reactions caused by bearings which are out of line can have serious effects on the life of rotating assemblies. Although bearings are normally aligned during assembly, thermal expansion of one or more supports can cause misalignment.

In misaligned shaft assemblies of two spans, stress-causing moments are easy to calculate by the influence-factor method.[1] However, for shafts of more than two spans, analysis becomes more complex. In this article the influence factor is employed to develop the moment equations for a three-span, nonuniform shaft system. Procedures developed can be used for systems with any number of spans.

Influence Factor Equations: From the previous article,[1] the influence factors, illustrated in Fig. 1, are defined by

$$\theta_b = \sum \frac{1}{12\,L^2\,E}\left[\frac{12\,a^2(dL) + dL^3}{I}\right] \qquad (1)$$

and

$$\theta_a = \sum \frac{1}{12\,L^2\,E}\left[\frac{12\,ab(dL) - dL^3}{I}\right] \qquad (2)$$

Moments and Reactions: For two-span shaft sys-

Nomenclature

a = Distance from center of dL to opposite support, in.
b = Distance from bearing where unit moment is applied to center of dL
dL = Length of arbitrary beam section, in.
L, L_a, L_b, L_c = Span lengths, in.
M_2 = Bending moment at support 2, lb-in.
M_3 = Bending moment at support 3, lb-in.
α_1 = Slope at bearing 2 on span a
α_2 = Slope at bearing 2 on span b
α_3 = Slope at bearing 3 on span b
α_4 = Slope at bearing 3 on span c
Δ = Bearing misalignment, in.
θ_a = Slope of elastic line of the defining span at support opposite support where moment acts
θ_b = Slope of elastic line of the defining span at support where unit moment acts
θ_{2a} = Slope at bearing 2 due to a unit moment at bearing 2 on span a
θ_{2b} = Slope at bearing 2 due to a unit moment at bearing 2 on span b
θ_{32} = Slope at bearing 2 due to a unit moment at bearing 3 on span b
θ_{23} = Slope at bearing 3 due to a unit moment at bearing 2 on span b
θ_{3b} = Slope at bearing 3 due to a unit moment at bearing 3 on span b
θ_{3c} = Slope at bearing 3 due to a unit moment at bearing 3 on span c

*Now with Industrial Gas Turbine Engineering, Westinghouse Electric Corp., Philadelphia, Pa.

[1] A. J. Scalzo—"Bearing Misalignment," MACHINE DESIGN, May 16, 1957, pp. 140-143.

tems, the influence factor defines the slope of the elastic line at the support where the unit moment is applied. For a three-span shaft system, moment equations are a function of the slope at the support opposite the unit moment, as well as the slope at the unit-moment support. Therefore, values for both slopes must be incorporated in the moment equations.

Furthermore, since influence-factor equations are based on a unit moment, slope due to the actual moment is the product of actual moment and influence factor. Bending moments are considered

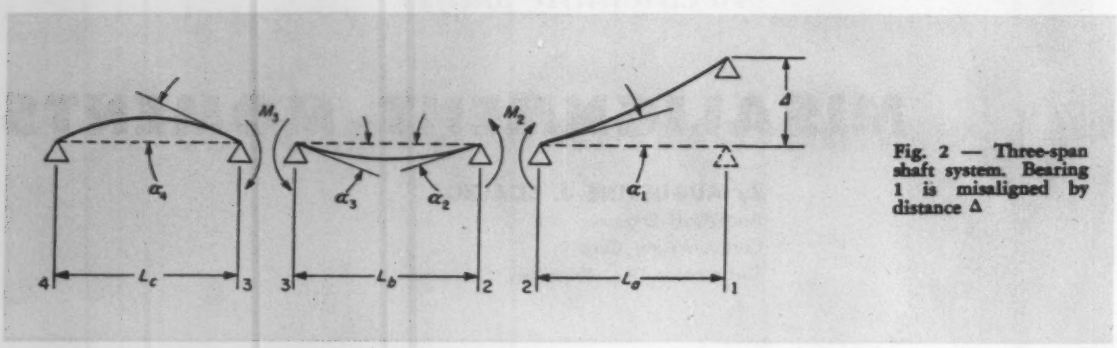

Fig. 2 — Three-span shaft system. Bearing 1 is misaligned by distance Δ

Example—Three-Span Shaft System

Problem is to determine bending moments at the mid-supports of a three-span shaft system, Fig. 6. Vertical thermal expansion of support 1 is assumed to be ¼ in. Table 1 illustrates a tabulation procedure that facilitates calculation of the influence factors.

Summation of the values tabulated in column 8 of Table 1 for sections 1, 2, and 3, gives

$$\sum \frac{1}{I}\left[\, 12\,a^2(dL) + dL^3 \,\right] = 48{,}901 \qquad \text{(E-1)}$$

Application of Equation 1 then gives the influence factor

$$\theta_{3c} = \sum \frac{1}{12\,L_c^2\,E}\left[\frac{12\,a^2(dL) + dL^3}{I}\right]$$

$$= \frac{48{,}901}{12(24^2)\,(30)\,(10^6)}$$

$$= 2.3583 \times 10^{-7} \qquad \text{(E-2)}$$

By a similar method, θ_{3b} can be calculated. From results of Table 1, the sum of values in column 8 for sections 4, 5, and 6 is

Table 1—Slope Parameters

1 Section	2 Slope	3 a (in.)	4 a^2 (in.^{2})	5 dL (in.)	6 dL^3 (in.^{3})	7 I (in.^{4})	8 $[12a^2\,(dL)+dL^3]/I$
1	θ_{3c}	5	25	10	1000	1	4000
2		12	144	4	64	12	581
3		19	361	10	1000	1	44320
4	θ_{3b}	34	1156	4	64	2	27776
5		17	289	30	27000	0.25	524160
6		1	1	2	8	2	16
4	θ_{2b}	2	4	4	64	2	128
5		19	361	30	27000	0.25	627840
6		35	1225	2	8	2	14704
7	θ_{2a}	21	441	10	1000	1	53920
8		13	169	6	216	20	619
9		5	25	10	1000	1	4000
		b					$[12\,ab\,(dL)-dL^3]/I$
4	θ_{32}	34	2	4	64	2	1600
5		17	19	30	27000	0.25	357120
6		1	35	2	8	2	416

$$\sum \frac{1}{I}\left[\, 12\,a^2(dL) + dL^3 \,\right] = 551{,}952 \qquad \text{(E-3)}$$

from which Equation 1 gives

$$\theta_{3b} = \sum \frac{1}{12\,L_b^2\,E}\left[\frac{12\,a^2(dL) + dL^3}{I}\right]$$

$$= \frac{551{,}952}{12(36^2)\,(30)\,(10^6)}$$

$$= 11.8302 \times 10^{-7} \qquad \text{(E-4)}$$

Similarly the slopes θ_{2b} and θ_{2a} are calculated from Equation 1 after summation of column 8, Table 1:

$$\theta_{2b} = \sum \frac{1}{12\,L_b^2\,E}\left[\frac{12a^2(dL) + dL^3}{I}\right]$$

$$= \frac{642{,}672}{12(36^2)\,(30)\,(10^6)}$$

$$= 13.7747 \times 10^{-7} \qquad \text{(E-5)}$$

$$\theta_{2a} = \sum \frac{1}{12\,L_a^2\,E}\left[\frac{12a^2(dL) + dL^3}{I}\right]$$

$$= \frac{58{,}539}{12(26^2)\,(30)\,(10^6)}$$

$$= 2.4054 \times 10^{-7} \qquad \text{(E-6)}$$

For the slope θ_{32}, the values in column 8 for sections 4, 5, and 6 are summed from Table 1:

$$\sum \frac{1}{I}\left[\, 12\,ab(dL) - dL^3 \,\right] = 359{,}136 \qquad \text{(E-7)}$$

Application of Equation 2 then gives

$$\theta_{32} = \sum \frac{1}{12\,L_b^2\,E}\left[\frac{12ab(dL) - dL^3}{I}\right]$$

$$= \frac{359{,}136}{12(36^2)\,(30)\,(10^6)}$$

$$= 7.6975 \times 10^{-7} \qquad \text{(E-8)}$$

positive if they place upper fibers of the beam in compression. Slopes are considered positive if angles of rotation are clockwise.

Fig. 2 illustrates a four-bearing system with bearing 1 misaligned by an amount Δ. Because the deflection curve is continuous at bearing 2, $\alpha_2 = \alpha_1$. Therefore,

$$-M_2\,\theta_{2b} + M_3\,\theta_{32} = -\frac{\Delta}{L_a} + M_2\,\theta_{2a} \tag{3}$$

Similarly, $\alpha_4 = \alpha_3$ at bearing 3, and

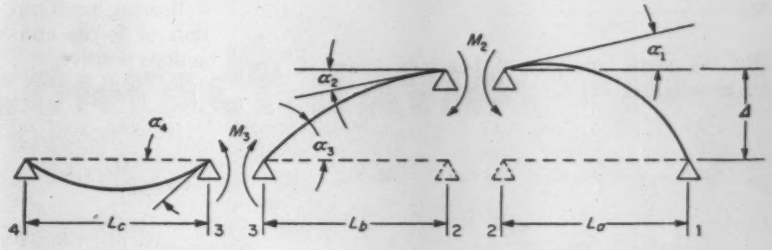

Fig. 3 — Three-span shaft system. Bearing 2 is misaligned by distance Δ

$$M_3\,\theta_{3c} = M_2\,\theta_{23} - M_3\,\theta_{3b}$$

which when simplified gives the absolute magnitude of the moment at support 3:

$$M_3 = \frac{M_2\,\theta_{23}}{\theta_{3b} + \theta_{3c}} \tag{4}$$

Examination of Equation 2 shows that $\theta_{23} = \theta_{32}$. Hence, the equation for the moment at support 2 is given by substituting Equation 4 in Equation 3 and replacing θ_{23} by θ_{32}:

$$M_2 = \frac{\frac{\Delta}{L_a}(\theta_{3b} + \theta_{3c})}{(\theta_{2a} + \theta_{2b})(\theta_{3b} + \theta_{3c}) - \theta_{32}^2} \tag{5}$$

Since M_2 places upper fibers in compression and M_3 places upper fibers in tension, M_2 is positive and M_3 is negative. Modifying the equations to conform to sign convention, Equation 4 becomes

$$M_3 = \frac{-M_2\,\theta_{32}}{\theta_{3b} + \theta_{3c}} \tag{6}$$

Similarly, with bearing 2 misaligned by an amount Δ, Fig. 3, $\alpha_2 = \alpha_1$ and $\alpha_4 = \alpha_3$. Hence, magnitude of the moments for this condition are found from

$$M_2 = \frac{\frac{\Delta}{L_a}(\theta_{3b} + \theta_{3c}) + \frac{\Delta}{L_b}(\theta_{3b} + \theta_{3c} + \theta_{32})}{\theta_{32}^2 - (\theta_{2a} + \theta_{2b})(\theta_{3b} + \theta_{3c})} \tag{7}$$

and

$$M_3 = \frac{\frac{\Delta}{L_b} - M_2\,\theta_{32}}{\theta_{3b} + \theta_{3c}} \tag{8}$$

The equations for moments when bearing 3 is misaligned by an amount Δ, Fig. 4, are arrived at

Value of moment M_2 is then calculated from Equation 5 as

$$M_2 = \frac{\frac{\Delta}{L_a}(\theta_{3b} + \theta_{3c})}{(\theta_{2a} + \theta_{2b})(\theta_{3b} + \theta_{3c}) - \theta_{32}^2}$$

$$= \frac{\frac{0.25}{26}(11.8302 + 2.3583)10^{-7}}{(16.1801)(14.1885)10^{-14} - [(7.6975)10^{-7}]^2}$$

$$= 8010 \text{ lb-in.} \tag{E-9}$$

With this value, the magnitude of the moment M_3 is determined from Equation 6 as

$$M_3 = \frac{-M_2\,\theta_{32}}{\theta_{3b} + \theta_{3c}}$$

$$= \frac{-(8010)(7.6975)10^{-7}}{(11.8302 + 2.3583)10^{-7}}$$

$$= -4346 \text{ lb-in.} \tag{E-10}$$

Reactions are determined from Equations 15, 16, 17, and 18 as

$$R_1 = \frac{M_2}{L_a} = \frac{8010}{26} = 308 \text{ lb}$$

$$R_4 = \frac{M_3}{L_c} = \frac{-4346}{24} = -181 \text{ lb}$$

$$R_2 = \frac{M_3 - R_1(L_a + L_b)}{L_b} = \frac{-4346 - 308(62)}{36}$$

$$= -651 \text{ lb}$$

$$R_3 = \frac{M_2 - R_4(L_b + L_c)}{L_b} = \frac{8010 + 181(60)}{36}$$

$$= 524 \text{ lb} \tag{E-11}$$

Shaft stresses can now be investigated in the manner discussed in the previous article.[1]

in the same manner and are found from

$$M_2 = \frac{\frac{\Delta}{L_c}\theta_{32} + \frac{\Delta}{L_b}(\theta_{3b} + \theta_{3c} + \theta_{32})}{(\theta_{3b} + \theta_{3c})(\theta_{2a} + \theta_{2b}) - \theta_{32}^2} \quad (9)$$

and

$$M_3 = \frac{\frac{\Delta}{L_b} - M_2(\theta_{2a} + \theta_{2b})}{\theta_{32}} \quad (10)$$

By the same analysis, if bearings 1 and 2 are both misaligned, Fig. 5,

$$\alpha_2 = \alpha_1$$

$$-\frac{\Delta}{L_b} + M_2\theta_{2b} - M_3\theta_{32} = -M_2\theta_{2a}$$

$$M_3 = \frac{M_2(\theta_{2a} + \theta_{2b}) - \frac{\Delta}{L_b}}{\theta_{32}} \quad (11)$$

and

$$\alpha_4 = \alpha_3$$

$$-M_3\theta_{3c} = -\frac{\Delta}{L_b} + M_3\theta_{3b} - M_2\theta_{23} \quad (12)$$

Substituting Equation 11 into Equation 12 and modifying sign to conform to the established convention,

$$M_2 = \frac{\frac{\Delta}{L_b}(\theta_{3b} + \theta_{3c} + \theta_{32})}{\theta_{32}^2 - (\theta_{2a} + \theta_{2b})(\theta_{3b} + \theta_{3c})} \quad (13)$$

and

$$M_3 = \frac{-M_2(\theta_{2a} + \theta_{2b}) - \frac{\Delta}{L_b}}{\theta_{32}} \quad (14)$$

Bearing reactions may be determined by summation of forces and moments. Assuming upward reactions positive,

$$R_1 = \frac{M_2}{L_a} \quad (15)$$

$$R_4 = \frac{M_3}{L_c} \quad (16)$$

$$R_2 = \frac{M_3 - R_1(L_a + L_b)}{L_b} \quad (17)$$

$$R_3 = \frac{M_2 - R_4(L_b + L_c)}{L_b} \quad (18)$$

$$R_1 + R_2 + R_3 + R_4 = 0 \quad (19)$$

The majority of shaft systems encountered in practice can be classified as either two or three-span shaft systems. However, when systems of more than three spans are investigated, the general approach used in the three-span development can be applied.

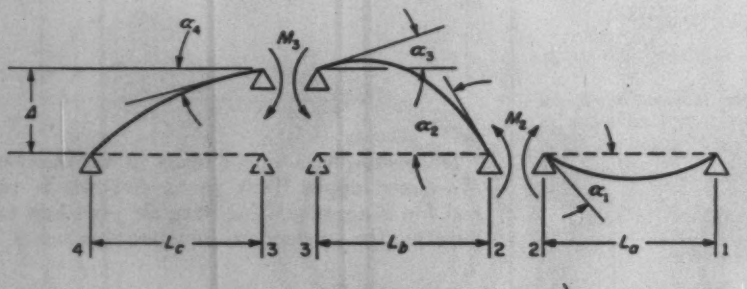

Fig. 4 — Three-span shaft system. Bearing 3 is misaligned by distance Δ

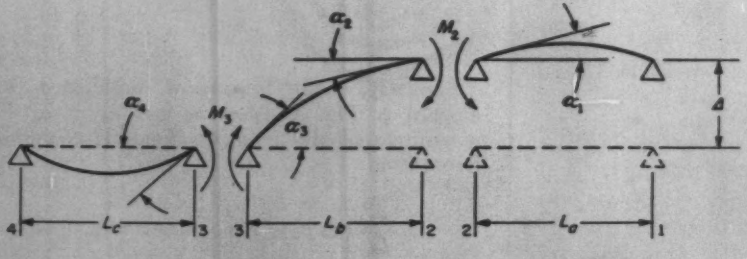

Fig. 5 — Three-span shaft system. Bearings 1 and 2 misaligned by distance Δ

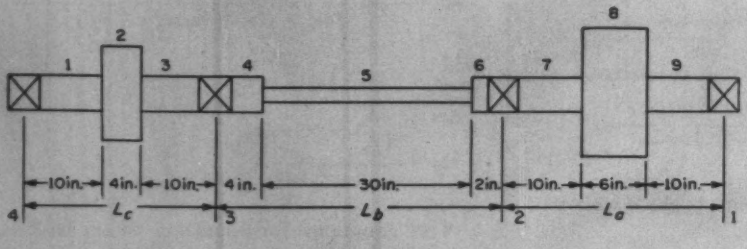

Fig. 6 — Three-span nonuniform shaft and bearing-support system

Do you design nonstandard involute gears? Simplify your calculations by using tables to find the proper

GEAR CONTACT RATIO

By **CHARLES TIPLITZ**
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AVERAGE number of gear teeth in contact, which is the gear contact ratio, is an important requirement for precision and smooth power transmission. This contact ratio is easy to determine for standard gears because reference tables are readily available. Such is not the case for gears which have extended or variable center distances. In this article, factors that affect the contact ratio of involute spur gears which mesh on fixed or variable centers are analyzed. From this analysis, tables are set up to simplify design problems.

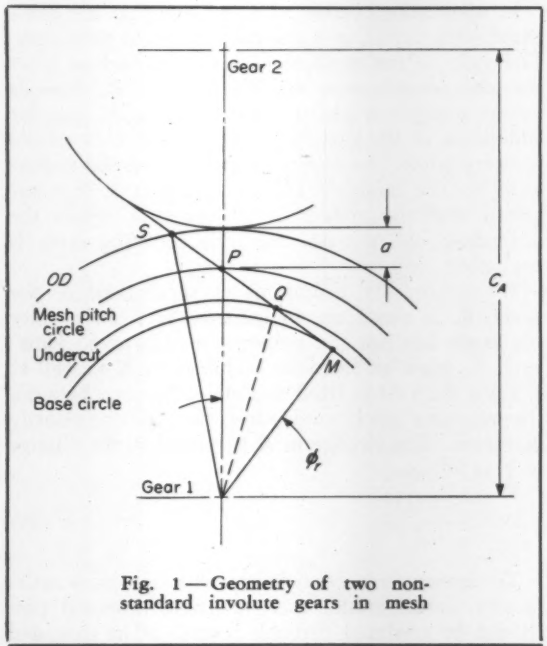


Fig. 1 — Geometry of two nonstandard involute gears in mesh

Factors Affecting Contact Ratios: Usually, the contact ratio increases with the number of teeth. This is not quite true for gears whose centers float. As the number of teeth increases, the finer the pitch becomes and the shorter the teeth. It follows that the shorter the teeth, the more the contact ratio drops as the gears separate. Actual ratios are presented here which permit precise determination of this variation for any operating condition. Thus it is possible to select appropriate design factors.

Equations presented here are derived from stand-

Nomenclature

a	= Gear addendum, in.
C	= Standard gear center distance for a given N and D_p, in.
C_A	= Actual gear center distance, in.
D_o	= Outside diameter of gear, in.
D_p	= Diametral pitch
K	= Contact ratio
m_p	= Total contact ratio
N	= Number of teeth
X	= Ratio of actual addendum (or dedendum) to standard
Y	= Index of extension, separation, or swell
θ	= Independent parameter
ϕ	= Hob pressure angle, deg
ϕ_A	= Actual pressure angle of gear pair for C_A, deg
	The following subscripts refer to
A	= Actual
a	= Tooth approach
r	= Tooth recession
1	= Gear 1
2	= Gear 2

ard gear formulas. In floating-center applications, the center distance is not controlled to suit gearing needs. Hence, the number of teeth and pitch are interdependent. Consequently, the expressions for contact ratios given here omit the pitch. The geometry of the gears under consideration is shown in Fig. 1.

Contact ratio during approach is calculated separately from that during recession. These calculations permit comparison of the pinion-recession value with the gear-approach value; the smaller of the two values is selected as the limiting contact ratio. The same choice is made between the gear-recession value and the pinion-approach value. The sum of these two limits is the contact ratio for the particular set.

In Fig. 1, SP is the contact line during approach of the gear teeth to the pitch point, P. The value for the contact ratio (see Nomenclature) during approach is given by

$$K_a = \frac{\sqrt{\left[\frac{(1+Y)N - 2X}{\cos\phi}\right]^2 - N^2} - N\tan\phi_r}{2\pi} \quad (1)$$

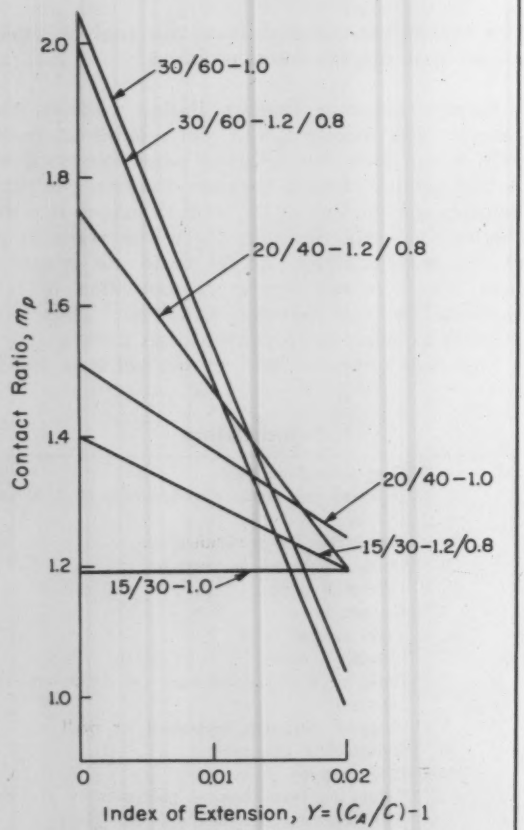


Fig. 2—Contact ratios for various gear sets. Gears have a 1:2 tooth ratio, a 14½-deg pressure angle, and a 0 to 0.02 index of extension of gear centers. Line ratios represent N_1/N_2-X_{a1}/X_{a2}

Table 1 gives solutions to this equation for values of X, Y and N, and for 14½ and 20-deg hobs. The value of X, ratio of actual to standard addendum, is usually assumed close to one for a first comparison. Successive comparisons then show which ratio is best for the specific gear combination. To relate the table to various gear designs, the following equations are used:

$$C = \frac{N_1 + N_2}{2D_p} \quad (2)$$

$$a = \frac{X}{D_p} \quad (3)$$

$$Y = \frac{C_A}{C} - 1 \quad (4)$$

$$\cos\phi = (1+Y)\cos\phi_r \quad (5)$$

As shown in Fig. 1, the contact line during recession of the gear tooth is PQ. Undercutting influences this portion of the analysis. The equation relating K_r, N, X, and Y is obtained most conveniently in terms of an independent parameter, θ, from which

$$K_r = \frac{N}{2\pi}(\tan\phi_r - \tan\theta) \quad (6)$$

and

$$\frac{N - 2X}{N} = \frac{3\theta - \tan\theta}{\tan(\phi + 2\theta) - \tan\phi} \quad (7)$$

Table 2 presents solutions to Equations 6 and 7 for various values of X, Y, N, and ϕ = 14½ and 20 deg. Table 3 gives values of K_r for various values of X and Y at values of N above which there is no undercutting.

In application, values of K_r of one gear are compared with values of K_a of the other and vice versa. The sum of the smallest of each comparison gives the total contact ratio, m_p. The value of K_a depends on the pressure angle, the number of teeth, and the addendum of the gear. Similarly, K_r depends on the pressure angle, the number of teeth, and the dedendum. In the Example and in Equation 3, it is assumed that the addendum of one gear equals the dedendum of its mate since the resulting error is negligible.

For consecutive extensions or separations of the gears, K_r is based on an increase in Y only, since the angle but not the undercutting changes. However, K_a must be based on a change in X as well as Y since the OD is fixed and the difference between the meshing pitch circle and the OD necessarily decreases. The change in X is related to the change in Y as follows:

$$\Delta X = \frac{-N(\Delta Y)}{2} \quad (8)$$

To determine a gear design with the most satisfactory contact ratio, each alternate proposed pair should be analyzed through several of its extended

Table 1—Contact Ratio During Approach For Nonstandard Involute Gears

		Pressure Angle, ϕ											
		14½ deg						20 deg					
		Number of Teeth, N											
Y	X	10	15	20	30	45	60	10	15	20	30	45	60
0.00	0.4	0.37	0.41	0.42	0.45	0.45	0.46	0.32	0.34	0.35	0.36	0.37	0.38
	0.6	0.51	0.56	0.58	0.63	0.66	0.68	0.46	0.48	0.50	0.53	0.54	0.56
	0.8	0.64	0.71	0.75	0.81	0.85	0.86	0.57	0.62	0.64	0.68	0.71	0.73
	1.0	0.76	0.84	0.89	0.97	1.03	1.08	0.68	0.74	0.78	0.83	0.87	0.89
	1.2	0.86	0.96	1.03	1.13	1.20	1.26	0.79	0.86	0.91	0.97	1.02	1.05
0.02	0.4	0.33	0.34	0.37	0.38	0.39	0.40	0.30	0.31	0.32	0.33	0.33	0.34
	0.6	0.46	0.50	0.52	0.55	0.57	0.58	0.42	0.44	0.46	0.48	0.49	0.50
	0.8	0.58	0.63	0.67	0.71	0.75	0.76	0.54	0.57	0.60	0.62	0.64	0.65
	1.0	0.69	0.75	0.80	0.85	0.90	0.93	0.65	0.69	0.72	0.76	0.79	0.80
	1.2	0.80	0.87	0.93	0.99	1.05	1.09	0.75	0.81	0.84	0.89	0.93	0.95
0.04	0.4	0.30	0.32	0.33	0.34	0.36	0.35	0.28	0.29	0.30	0.30	0.30	0.31
	0.6	0.43	0.45	0.47	0.49	0.52	0.51	0.40	0.41	0.43	0.44	0.46	0.46
	0.8	0.54	0.58	0.61	0.63	0.67	0.67	0.51	0.54	0.56	0.57	0.59	0.60
	1.0	0.65	0.70	0.74	0.77	0.82	0.83	0.62	0.65	0.68	0.70	0.73	0.74
	1.2	0.75	0.81	0.86	0.90	0.97	0.98	0.72	0.77	0.80	0.83	0.86	0.88
0.08	0.4	0.27	0.27	0.28	0.28	0.28	0.29	0.25	0.26	0.26	0.26	0.27	0.27
	0.6	0.38	0.40	0.41	0.42	0.41	0.43	0.37	0.38	0.38	0.39	0.40	0.40
	0.8	0.49	0.51	0.53	0.54	0.56	0.57	0.47	0.49	0.50	0.50	0.53	0.53
	1.0	0.59	0.63	0.64	0.67	0.69	0.72	0.57	0.60	0.61	0.63	0.65	0.66
	1.2	0.69	0.73	0.76	0.79	0.82	0.84	0.67	0.70	0.72	0.75	0.77	0.78

Table 2—Contact Ratio During Recession For Nonstandard Involute Gears

		Pressure Angle ϕ						
		14½ deg				20 deg		
		Number of Teeth, N						
Y	X	10	15	20	30	10	15	20
0.00	0.4	0.36	—	—	—	—	—	—
	0.6	0.26	0.54	—	—	0.57	—	—
	0.8	0.18	0.44	0.72	—	0.54	—	—
	1.0	0.11	0.35	0.62	1.20	0.41	0.81	—
	1.2	0.05	0.27	0.52	1.07	0.34	0.73	1.14
0.02	0.4	0.48	—	—	—	—	—	—
	0.6	0.38	0.71	—	—	0.66	—	—
	0.8	0.30	0.61	0.95	—	0.63	—	—
	1.0	0.24	0.53	0.85	1.55	0.50	0.95	—
	1.2	0.17	0.45	0.76	1.42	0.44	0.87	1.32
0.04	0.4	0.57	—	—	—	—	—	—
	0.6	0.48	0.86	—	—	0.75	—	—
	0.8	0.40	0.76	1.14	—	0.72	—	—
	1.0	0.33	0.67	1.05	1.84	0.59	1.07	—
	1.2	0.26	0.59	0.95	1.71	0.52	0.99	1.49
0.08	0.4	0.73	—	—	—	—	—	—
	0.6	0.64	1.10	—	—	0.90	—	—
	0.8	0.56	1.00	1.47	—	0.86	—	—
	1.0	0.49	0.91	1.37	2.32	0.73	1.30	—
	1.2	0.43	0.84	1.28	2.30	0.67	1.21	1.78

Table 3—Contact Ratio For Gears Without Undercutting

		Pressure Angle ϕ												
		14½ deg							20 deg					
		Number of Teeth, N												
Y	X	12.77	19.1	25.5	31.8	38.2	45	60	10.26	13.7	17.1	20.5	30	45	60
0.00	0.4	0.52													
	0.6		0.79						0.59						
	0.8			1.05						0.79					
	1.0				1.31						0.99				
	1.2					1.57	1.87	2.49				1.19	1.73	2.61	3.48
0.02	0.4	0.67													
	0.6		1.01						0.69						
	0.8			1.35						0.92					
	1.0				1.68						1.15				
	1.2					2.01	2.38	3.17				1.38	2.02	3.02	4.03
0.04	0.4	0.80													
	0.6		1.20						0.77						
	0.8			1.59						1.03					
	1.0				1.98						1.29				
	1.2					2.38	2.79	3.74				1.54	2.27	3.39	4.53
0.08	0.4	1.00													
	0.6		1.50						0.92						
	0.8			2.00						1.23					
	1.0				2.49						1.54				
	1.2					3.00	3.54	4.72				1.85	2.71	4.06	5.41

positions. The plot of m_p over this range for each pair can then be compared.

Example: Assume that gears are to be designed for an 8-in. roll mill which has a maximum roll separation of 0.16 in. Also assume that a gear ratio of 2:1 and an actual hob pressure angle of 14½ deg are given.

From these assumptions, $C = 8$ in. and $C_A = 8.16$ in., and from Equation 4, it is found that $0 < Y < 0.02$.

As a first trial, values of $N_1 = 20$ and $X_{a1} = 1.2$ are selected for gear 1 and $N_2 = 40$, $X_{a2} = 0.8$ for gear 2. From Tables 1 and 2, the following values are obtained for $Y = 0$:

Table	N	X	Y	K
1	20	1.2	0	1.03
	40	0.8	0	0.84
2	20	0.8	0	0.72
	40	1.2	0	1.65

Comparing the contact ratio of gear 1 during approach with that of gear 2 during recession, it is found that $1.03 < 1.65$. A similar comparison of K values during approach of gear 2 and recession of gear 1 shows that $0.72 < 0.84$. When $Y = 0$, the sum of the smaller value in each comparison is the total contact ratio for these conditions $m_p = 1.03 + 0.72 = 1.75$.

When the gears are separated, $Y = 0.02$, and it is necessary to calculate the change in X for this change in Y.

From Equation 8, $\Delta X_1 = -20(0.02/2) = -0.20$ and $\Delta X_2 = -40(0.02/2) = -0.40$. Hence, the new value of X for gear 1 is $X_{a1}' = X_{a1} + \Delta X_1 = 1.20 + (-0.20) = 1.0$ and for gear 2 is $X_{a2}' = X_{a2} + \Delta X_2 = 0.80 + (-0.40) = 0.4$.

For these new values of X, the contact ratios, when $Y = 0.02$, are found from Tables 1 and 2.

Table	N	X	Y	K
1	20	1.0	0.02	0.80
	40	0.4	0.02	0.39
2	20	0.8	0.02	0.95
	40	1.2	0.02	2.11

From which $m_p = 1.19$.

Comparisons of other gears with different numbers of teeth and values of X are tabulated as follows:

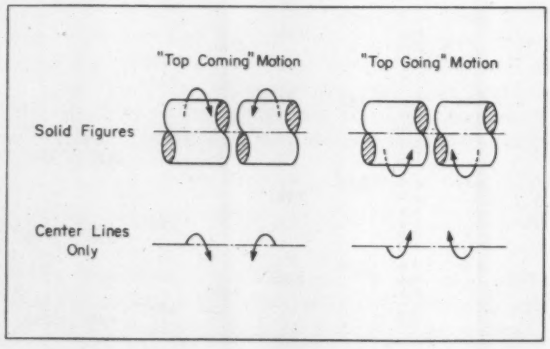
Y	N_1 / N_2	15 / 30	20 / 40	30 / 60	15 / 30	20 / 40	30 / 60
0	X_{a1}	1.2	1.2	1.2	1.0	1.0	1.0
	X_{a2}	0.8	0.8	0.8	1.0	1.0	1.0
	K_{a1}	0.96	1.03	1.13	0.84	0.89	0.97
	K_{r1}	0.44	0.72	—	0.35	0.62	1.20
	K_{a2}	0.81	0.84	0.86	0.97	1.01	1.08
	K_{r2}	1.07	1.65	—	1.20	—	—
0.02	X_{a1}	1.05	1.00	0.90	0.85	0.80	0.70
	X_{a2}	0.50	0.40	0.20	0.70	0.60	0.40
	K_{a1}	0.78	0.80	0.78	0.66	0.67	0.63
	K_{r1}	0.61	0.95	—	0.53	0.85	1.55
	K_{a2}	0.41	0.39	0.20	0.62	0.57	0.40
	K_{r2}	1.42	2.11	—	1.42	—	—
0	m_p	1.40	1.75	1.99	1.19	1.51	2.05
0.02	m_p	1.19	1.19	0.98	1.19	1.24	1.03

The results of this tabulation are shown graphically in Fig. 2, from which it can be seen that a 20/40 gear pair with an X value of 1 during both approach and recession is the best combination, since it gives the maximum contact ratio at the extended center distance. Using this combination, Equation 2 gives $D_p = (20 + 40)/2(8) = 3.75$. From the equation for outside diameter of the gear, $D_o = 2X/D_p + N/D_p$, then $D_{o1} = 2(1.0)(1/3.75) + (20/3.75) = 5.86$ in. Similarly, $D_{o2} = 11.2$ in. If gears of this diametral pitch were not available, a set of gears with another D_p could be analyzed in a similar manner to obtain the required overall dimensions and characteristics.

Tips and Techniques

Rotational Arrows

Arrows used to indicate rotational direction are often the source of misunderstanding on drawings. A simple and clear method of indicating direction of rotation on items such as shafts, gears and clutches is accomplished by starting the solid tail of the line at the edge or center line of the piece and allowing the arrow to follow in the required rotational direction. The dotted lines may be added for additional clarity.—ERNST A. KREMEYER, *Anderson Bros. Mfg. Co., Rockford, Ill.*



DESIGN ABSTRACTS

bearings

Elastic and Damping Properties Of Cylindrical Journal Bearings

B. Sternlicht, General Electric Co.

Techniques for calculation of fluid stiffness and dissipation functions for journal bearings. Values for these parameters are given as functions of eccentricity ratio and are determined from the solution of Reynolds two-dimensional equation with squeeze-film considerations included. The analysis is applicable to any bearing geometry.

ASME paper 58-LUB-3, from ASLE-ASME Lubrication Conference, Los Angeles, October, 1958; 7 pp.

Analysis and Characteristics of The Three-Lobe Bearing

O. Pinkus, General Electric Co.

An analytical solution of three-lobe journal bearings based on the solution of the finite Reynolds equation. Expressions for eccentricity, lubricant flow, power loss, and spring constant are given for a range of L/D ratios and ellipticities. Charts and equations for setting design requirements and calculating performance are given in simple convenient form.

ASME paper 58-LUB-2, from ASLE-ASME Lubrication Conference, Los Angeles, October, 1958; 7 pp.

Axial, Relative Motion of A Circular Step Bearing

L. Licht, The Franklin Institute Laboratories

Development of equations relating flow of lubricant and axial motion of an externally pressurized thrust bearing. The bearing is shown to be stable when the fluid is incompressible. Expressions for local stiffness and damping coefficients for evaluation of dynamic response of the bearing are given. An analog computer solution of the equation of motion is compared with results of the corresponding, small-displacement equation.

ASME paper 48-LUB-1, from ASLE-ASME Lubrication Conference, Los Angeles, October, 1958; 16 pp.

Performance of Hydrodynamic Gas-Lubricated Bearings

A. Burgdorfer, The Franklin Institute Laboratories

A modified Reynolds equation derived for gas-lubricated hydrodynamic bearings operating under slip flow conditions. Analytical solutions are given for a Rayleigh type step bearing and an inclined plane slider bearing for the case of two-dimensional flow. Influence of the molecular mean free path on bearing performance is obtained by means of a perturbation technique.

ASME paper 58-LUB-7, from ASLE-ASME Lubrication Conference, Los Angeles, October, 1958; 5 pp.

electrical

Dynamic Effects On Airborne Electronics

C. A. Golueke, Wright Air Development Center

Coverage of specific vibration levels that general airborne electronic components can withstand without benefit of vibration isolators. Applicability and function of vibration isolators are briefly covered.

SAE paper 83D, SAE National Aeronautic Meeting, Los Angeles, September, 1958; 6 pp.

The Turbonator—An Integrated Air-Turbine Generator

S. F. Richardson and J. W. Haynes, General Electric Co.

A discussion of the features of an air turbine designed to produce electrical power without requiring external cooling. An integral construction is described which shows the practicality of using turbine exhaust to cool an aircraft generator. Inherent cooling characteristics of the turbine match the cooling requirements of the generator and, as electrical load increases, increased temperature drops across the turbine match increased generator losses. These and other design features of the turbonator are described.

SAE paper 94B, SAE National Aeronautic Meeting, Los Angeles, September, 1958; 5 pp.

materials

Designing With Molybdenum

R. W. Yancey, Fansteel Metallurgical Corp.

How various molybdenum parts can be produced by methods similar to those by which molybdenum tube components are made. Methods of deep drawing and spinning are discussed, and tensile properties and elongation of molybdenum wire at temperatures to 1100 F are included. Some applications of molybdenum wire of various sizes are included together with techniques for

fastening, brazing, and welding.

From Fansteel Metallurgy, *September*, 1958; *pp.* 2-4.

Radiation Resistant ANP Turbine Lubricants

J. M. Clark Jr. and G. C. Lawrason, Southwest Research Institute

Results of a program involving testing of lubricants and fuels under dynamic conditions supplemented by additional stress of high-level radiation.

SAE paper 92D, SAE National Aeronautic Meeting, Los Angeles, September, 1958; 9 *pp.*

Characteristics and Properties Of Porcelain Enamel

A brief treatment of the qualities, properties, and design potentials of porcelain enamel coatings. Physical and chemical properties are tabulated.

Porcelain Enamel, *Vol.* 6, *No.* 2, *pp.* 4-5.

Plastics at High Temperatures

I. J. Gruntfest, General Electric Co.

A discussion of the usefulness of organic plastics for skins of hypersonic vehicles. Chemical considerations of the plastics are shown to be as crucial in materials selection as mechanical and physical properties.

SAE paper 82A, SAE National Aeronautic Meeting, Los Angeles, September, 1958; 4 *pp.*

mechanical

Principles and Applications Of the Free-Piston Engine

G. Flynn Jr., General Motors Corp.

A summary of design characteristics of the free-piston engine. Operational diagrams, advantages, and limitations of the engine, and applications for marine and automotive use are included.

General Motors Engineering Journal, *Vol.* 5, *No.* 3, *July-August-September,* 1958; *pp.* 22-27.

Large Deflections Of Stiffened Plates

W. G. Soper, Los Alamos Scientific Laboratory

A treatment of the problems of nonlinear deflection of orthogonally stiffened plates subjected to static lateral load using the concept of equivalent orthotropic plates. Equations are derived which are appropriate generalizations of Von Karman's equations for isotropic plates. Rectangular plates are considered in detail, and an approximate solution is obtained through trigonometric series.

ASME paper 58-APM-18, West Coast Conference of Applied Mechanics Division, Los Angeles, September, 1958; 5 *pp.*

Static and Total Temperatures Of High-Velocity Gas Streams

K. Woodfield and R. Bloomfield, General Motors Corp.

An approach to problem-solving involving heat transfer in a moving gas stream. How high-temperature and high-velocity gases influence thermocouple temperature measurements.

General Motors Engineering Journal, *Vol.* 5, *No.* 3, *July-August-September,* 1958; *pp.* 53-54.

The Patentability of New Uses for Old Devices

P. J. Reising, General Motors Corp.

An explanation of how and when it is possible to obtain a patent on a new use for an old product. An example is used to illustrate the point. General procedure for patent application is outlined.

General Motors Engineering Journal, *Vol.* 5, *No.* 3, *July-August-September,* 1958; *pp.* 41-42.

Constant-Speed Drives

C. W. Helsley Jr., North American Aviation Inc.

A discussion of the ability of various types of constant-speed drives to meet performance requirements of high-mach aircraft. The constant-speed drive is defined for the purpose of discussion and is classified into hydraulic, mechanical, and pneumatic types. Features of each type are covered.

SAE paper 94A, "Adaptation of Constant Speed Drives to Long-Range Manned Aircraft of the Immediate Future," SAE National Aeronautic Meeting, Los Angeles, September, 1958; 15 *pp.*

Space-Cabin Design

E. G. Aken, Convair and E. B. Konecci, Douglas Aircraft Co. Inc.

A two-part treatise on design factors involved in designing space cabins. Part 1 deals with thermal and gravitational design considerations, and Part 2 covers problems of respiration and decompression which concern the human occupant.

SAE paper 90B, SAE National Aeronautic Meeting, Los Angeles, September, 1958; 23 *pp.*

Some Solutions of the Timoshenko Beam Equation

H. J. Plass Jr., The University of Texas

Solutions of the Timoshenko beam equation for short pulse-type loading. Type of support and impact conditions are included. Results are found numerically by the method of characteristics, and differences between various cases are studied.

ASME paper 58-APM-3, West Coast Conference of the Applied Mechanics Division, Los Angeles, September, 1958; 7 *pp.*

The Floated Gyroscope

W. G. Denhard, Massachusetts Institute of Technology

A description of the general characteristics of the floated, single-degree-of-freedom, integrating gyroscope and how it provides inertial reference or co-ordinate systems which indicate latitude and longitude on earth or the pathway to a star. Materials of gyro construction, bearings, drive motors, and stabilizing elements are covered.

ARS paper 659-58, from ARS Fall Meeting, Detroit, Mich., September, 1958; 9 *pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 25 cents to members, 50 cents to nonmembers.

SAE—Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

Fansteel Metallurgy, Fansteel Metallurgical Corp., Metals & Fabrication Div., North Chicago, Ill.

Porcelain Enamel, Porcelain Enamel Institute, Associations Bldg., 1145 19th St., Washington 6, D. C.

General Motors Engineering Journal, G. M. Technical Center, P. O. Box 177, North End Station, Detroit 2, Mich.

ARS—American Rocket Society, 500 Fifth Ave., New York 36, N. Y.

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Upgrading Steel Parts

How the Chromalloy process for diffusion of chromium into the surface of metals upgrades parts is described in illustrated Bulletin 29. Process makes it possible to select a low cost steel as the base metal and confine expensive alloying to the surface. 4 pages. Chromalloy Corp., 450 Tarrytown Rd., White Plains, N. Y. D

Circle 631 on Page 19

Military Switches

Design features, dimensional drawings, rating tables, and general information on positive action military switches are contained in Catalog EA-168. Covered are toggle lever environment sealed, lever sealed, lever lock environment sealed, and lever sealed single, double, and four-pole types. 12 pages. Cutler-Hammer Inc., Milwaukee 1, Wis. K

Circle 632 on Page 19

Air-Cooled Condenser

Selection, installation, operation, and maintenance data on the Zephyrcon air-cooled condenser are presented in this engineering manual. Quick and exact selection methods are covered, as is multiple circuiting of condensers. Tables, capacity charts, and drawings of typical installations are included. 24 pages. Larkin Coils, Inc., Box 1699, Atlanta. Ga. A

Circle 633 on Page 19

Compressors

Design and construction data are presented as an aid to proper selection and application of medium pressure line of Spiraxial compressors in illustrated Bulletin LAH-158. Capacities from 1000 to 12,000 cfm for pressures up to 15 psi are covered for 17 sizes. Ratings of each are given. 4 pages. Dresser Industries, Inc., Roots-Connersville Blower Div., 900 W. Mount St., Connersville, Ind. J

Circle 634 on Page 19

Dust Control Hose

Inserted in 4-page illustrated Bulletin 82 are 11 pictorial sheets which show applications of Flexaust hose and Portovent duct in the control of dust in various types of operations. Material specs, selection data, and prices are included. Flexaust Co., 100 Park Ave., New York 17, N. Y. D

Circle 635 on Page 19

Forgings & Alloy Steel

Pictorial treatment of the many steps involved in producing custom-made steel products, from melting of metal to heat treating, machining, and testing is found in brochure "Custom Steel Makers to Industry." Various finished products made from forgings are shown and discussed. 24 pages. Midvale-Heppenstall Co., Philadelphia 40, Pa. E

Circle 636 on Page 19

Electro-Mechanical Kits

Features and specifications on Servoboard electro-mechanical assembly components, including hangers, clamps, shafts, bearings, gears, limit stops, switch assemblies, clutches, and differentials are content of Catalog TDS-1110-1. Parts may be purchased individually or in four kits. 16 pages. Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y. D

Circle 637 on Page 19

Porcelain Enameled Parts

Functional and decorative applications and physical properties of small porcelain enameled metal parts are discussed in illustrated Brochure SC-58. Mechanical, electrical, chemical, thermal, and sanitary uses are covered. 4 pages. Erie Ceramic Arts Co., 3120 W. 22nd St., Erie, Pa. F

Circle 638 on Page 19

Lubrication Pumps

Hydra-Lube single and double-acting pumps in the HLS Series, designed for the automatic lubrication of machine tools and other equipment through Type M feeder systems, are subject of Data Sheet 5533. Reservoir assemblies for oil and grease are also shown. 2 pages. Trabon Engineering Corp., 28815 Aurora Rd., Solon, Ohio. F

Circle 639 on Page 19

Test Equipment

Details of test equipment for electronics, electrical, air conditioning, and heat equipment industries are contained in Brochure 2060. Included are volt, ohm, and ampere meters, temperature meters, microtesters, color bar generators, tube testers, and many others. 8 pages. Simpson Electric Co., 5200-18 W. Kinzie St., Chicago 44, Ill. I

Circle 640 on Page 19

Electrical Equipment

Special and standard machine drive systems, traction and lift motors, inverters, generators, motor-generators, motor-alternators, and high frequency power equipment are briefly described in illustrated folder. It also covers various control equipment. 6 pages. Safety Industries, Inc., Electrical Div., Box 904, New Haven 4, Conn. B

Circle 641 on Page 19

Valves

Quick-As-Wink Slim Line solenoid, lever, or ball-actuated valves, described in illustrated Bulletin 581, are suited for controlling small cylinders or operating various devices. Operation is on air, oil, or acidic water. 4 pages. Hunt Valve Co., Salem, Ohio. G

Circle 642 on Page 19

Capillary Tubing

Lengths up to 3000 ft, tested for flow rate when required, are available in the capillary tubing described in illustrated Data Memorandum 11. Materials in which produced, tolerances, finishes, inspections, and other data are presented. 6 pages. Superior Tube Co., 1578 Germantown Ave., Norristown, Pa. E

Circle 643 on Page 19

Timing Controls

Recycling, time delay, interval, and elapsed time explosionproof timing controls are described and illustrated in Bulletin 800. Specifications, dimensional drawings, and gear rack data are given for all models. 8 pages. Industrial Timer Corp., 1407 McCarter Highway, Newark 4, N. J. D

Circle 644 on Page 19

Flexible Couplings

Flexring couplings, subject of illustrated Data Sheet 61, are offered in four sizes for 0.28 to 4.66 hp at 1000 rpm. Their design and specifications are given. 2 pages. John Waldron Corp., River Road, New Brunswick, N. J. D

Circle 645 on Page 19

Low Pressure Compressors

Specifications on three models of heavy duty, low pressure compressors ranging in capacity from 756 to 7392 cfm are presented in illustrated Bulletin A-95. Design is shown in a sectional drawing. 8 pages. Joy Mfg. Co., Henry W. Oliver Bldg., Pittsburgh 22, Pa. F

Circle 646 on Page 19

Precision Spindles

Standard and special spindles for grinding, boring, and other machining operations are subject of Bulletin S-16. Features such as wheel holders and interchangeable expansion arbors are covered, also. 4 pages. Pope Machinery Corp., 261 River St., Haverhill. Mass. B

Circle 647 on Page 19

H. J. Birchal

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For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

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Circle 482 on Page 19

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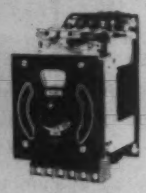

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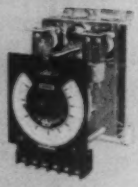

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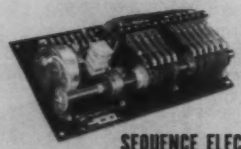

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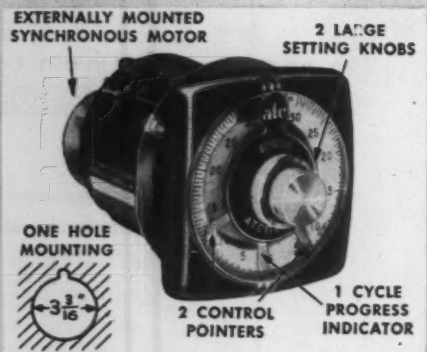

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In-Line Mechanisms

Offered as a new approach to subsystem module design, in-line mechanisms make for optimum utilization of space and weight by coaxial mounting of rotary components on a common shaft. The mechanisms are described and their uses and specifications given in illustrated folder. 4 pages. Spectrol Electronics Corp., 1704 S. Del Mar Ave., San Gabriel, Calif. M

Circle 648 on Page 19

Drawn Aluminum Boxes

Over 11,000 standard deep drawn aluminum boxes and covers are available from stock, according to data in illustrated Catalog B. Sizes range from ⅞ x 1⅝ in. to 20⅛ x 32⅛ in. and heights from ⅞ to 10 in. Any size can be customized by punching, welding, painting, louvering, or other operations. 20 pages. Zero Mfg. Co., 1121 Chestnut St., Burbank, Calif. L

Circle 649 on Page 19

Snap-Acting Switches

Illustrated Bulletin 858A describes Unimax Type A precision snap-acting switches for use in appliances, vending machines, automatic devices, signal and alarm systems, and automatic controls. Ratings, circuit arrangements, and specifications are included. 4 pages. W. L. Maxson Corp., Unimax Switch Div., Ives Road, Wallingford, Conn. B

Circle 650 on Page 19

Axial Flow Fans

Designed to provide high air displacement and pressure for cooling, heating, and ventilating, Pesco axial flow fans described in Bulletin 5802 can be used in aircraft, marine, electronic, commercial, and other installations. Capacities range from 16 to 4650 cfm with static pressures to 16 in. 4 pages. Borg-Warner Corp., Pesco Products Div., 24700 N. Miles Rd., Bedford, Ohio. G

Circle 651 on Page 19

Sintered Bearings & Parts

Prices, dimensions, and engineering data on a complete line of Graphex, Coprex, and Woodex oilless and self-lubricating bearings, bushings and machine parts are presented in comprehensive 1958 Catalog. Design, production, and performance information as well as properties of sintered metals are covered. 72 pages. Wakefield Bearing Corp., 29-99 Foundry St., Wakefield, Mass. B

Circle 652 on Page 19

Environmental Chambers

"Controlled Atmosphere Conditions" is title of manual on environmental chambers for research, testing, subzero metal treatment, rivet cooling, and many other purposes. Technical data are presented on atmospheric properties, temperature conversion, metal shrinkage, relative humidity, and altitude conversion. 28 pages. Webber Mfg. Co., Box 217, Indianapolis 6, Ind. J

Circle 653 on Page 19

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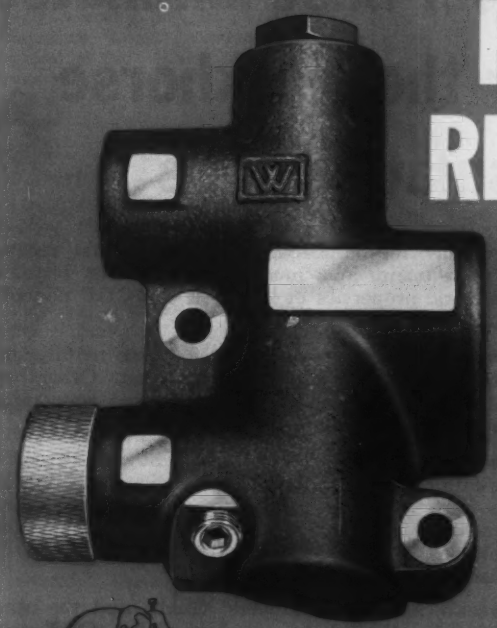
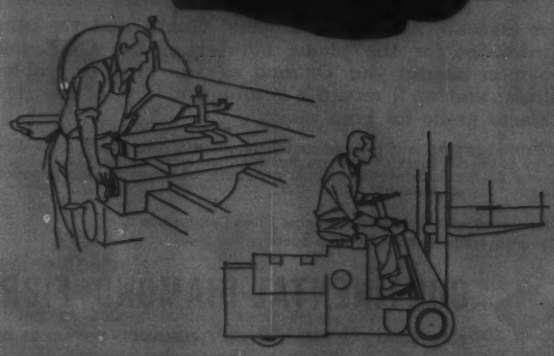


with manually adjustable PRESSURE SETTINGS

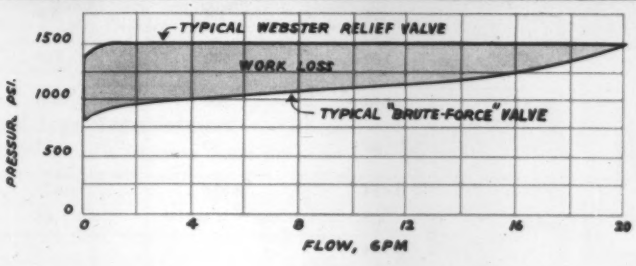
INSTANT ADJUSTMENT of pressure settings makes Webster's new pilot operated relief valve an ideal and *wise* choice for industrial applications. Knurled knob permits quick manual changes in pressure settings . . . from 500 to 2000 psi. Valve is also available with adjusting screw and sealing cap instead of knurled knob. Both models are available in two sizes — 0 to 20 gpm and 0 to 60 gpm.

In addition, there are the proved advantages of Webster's clog-free performance, quieter operation, quality construction . . . at a price competitive with the lowest.



BOOSTS WORK OUTPUT 38.5%!

Full speed power up to 93% of relief setting with the Webster pilot operated relief valve! And the graph shows it . . . typical performance curve illustrates minimum pressure drop and instant response of Webster pilot valve over "brute-force" type. 38.5% work bonus!



franklin ad- H-112

call the man from Webster

His intimate knowledge of this new relief valve and its many advantages can help in adapting it to your product.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

- ☐ *Have THE MAN FROM WEBSTER contact us —*
- *— Please send the following:*
- ☐ *Bulletin H3A3 covering the new Webster pilot operated relief valve*
- ☐ *Complete hydraulic catalog of pumps, valves and fluid motors*
- ☐ *New information or data as published*

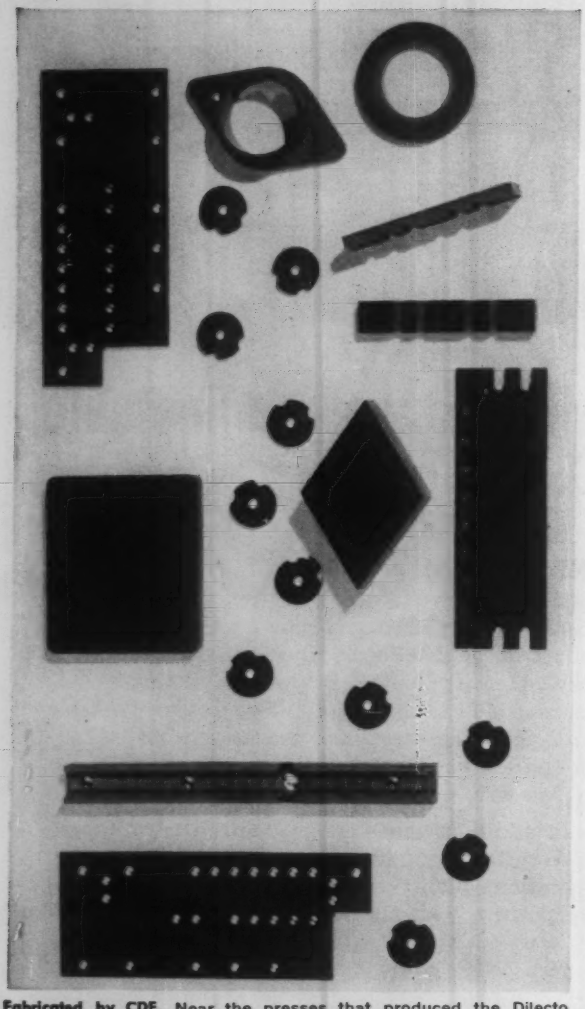
Name.....

Title.....

Company.....

City.....State.....

Circle 484 on Page 19



Fabricated by CDF. Near the presses that produced the Dilecto laminates, these paper-base parts were machined to close tolerances by CDF specialists . . . quickly, accurately, economically for the purchasers. This is a random selection from the five grades described in the table below.

CDF Dilecto® paper-base laminates for the workhorse insulation jobs

For everyday mechanical-electrical parts that receive tough punishment and must have excellent physical and dielectric properties at low cost, the CDF phenolic paper-base line is outstanding.

Economy. CDF paper-base grades machine readily into intricate parts. Some are flame-retardant. Others are especially adaptable for punching. All are economical for the value delivered.

Fabrication Facilities. CDF has excellent and extensive plastics-fabrication facilities for turning out finished Dilecto parts to your specifications—better and more economically than you can do it yourself. Save the time and trouble of intricate fabrication by using CDF's specialized facilities.

See Sweet's, Electronics Buyers' Guide, and the other directories for the phone number of the CDF sales engineer nearest you. Or send us your print or problem direct, and we'll return a recommendation of the right Dilecto grade for your need.

CDF makes Di-Clad* printed-circuit laminates, Diamond* Vulcanized Fibre, CDF products of Teflon†, flexible insulating tapes, Dilecto* laminated plastics, Celoron* molded products, Micabond* mica products, Spiral Tubing, Vulcoid*.

*Trademark of Continental-Diamond Fibre Corporation
†Du Pont trademark for its TFE-fluorocarbon resin

CDF

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 23, DEL.

Typical Property Values—Dilecto Paper-Base Laminates in Sheet Form

	X-13 (NEMA X)	XP-13 (NEMA P)	XX-13 (NEMA XX)	XX-13 FR (Fire-retardant) (NEMA XX)	XXXP-28 (NEMA XXXP)
ROCKWELL HARDNESS (M SCALE)	100	95	110	108	90
TENSILE STRENGTH lw (1000 psi.)	20	12	16	17	12
FLEXURAL STRENGTH lw (1000 psi.)	27	16	17	20	18
COMPRESSIVE STRENGTH (1000 psi.)	40	25	35	41	22
WATER ABSORPTION (% in 24 hrs.) 1/16" thickness	3.5	3.0	1.4	1.2	0.6
MAXIMUM CONTINUOUS OPERATING TEMPERATURE (°C.)	120	120	120	120	120
DIELECTRIC STRENGTH perp. to lam. (VPM)	800	800	650	700	800
DIELECTRIC STRENGTH parallel to lam. (Kv.)	50	50	60	70	75
DISSIPATION FACTOR at 1 mc, Cond. A	0.042	0.038	0.034	0.038	0.027
DIELECTRIC CONSTANT at 1 mc, Cond. A	5.5	4.6	4.7	4.8	3.6
ARC-RESISTANCE (seconds)	8	4	4	10	10
INSULATION RESISTANCE (megohms) ASTM D-257, Fig. 3	100	100	1,000	1,000	600,000
AIEE insulation class	A	A	A	A	A

Circle 485 on Page 19

Pneumatic Check Valve

Data Sheet F-8791 deals with a 1½-in. pneumatic check valve for checking rapidly reversing, high temperature, high pressure air surges. It withstands temperatures to 800° F and is designed for service at up to 150 psi. 1 page. Barber-Colman Co., Aircraft Controls Div., Rockford, Ill. K

Circle 654 on Page 19

Die Steel

Applicable to blanking and forming punches, dies, and rolls; cold or hot trimmer, plastic molding, straightening, and bending dies; and precision gages, Sagamore-EZ free-machining air-hardening die steel is subject of illustrated Blue Sheet. 4 pages. Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa. F

Circle 655 on Page 19

Valve Actuator

Bulletin A-900 explains design and operating principle of the Thermo-Drive actuator which provides for critical positioning of a valve or other control element in accordance with signals or demands from elements of a circuit. 4 pages. Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio. G

Circle 656 on Page 19

RF Coaxial Connectors

Details of a complete line of lightweight radio frequency coaxial plugs and cable connectors are presented in Catalog ALRF-1. Aluminum shells contribute to weight reduction. 17 pages. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif. L

Circle 657 on Page 19

Engine Controls

Engine controls described and priced in Catalog H include cooling water regulators of safety, temperature regulator, and pressure operated valve types. Complete specifications and application data are included. 32 pages. Robertshaw-Fulton Controls Co., Fulton Sylphon Div., Knoxville 1, Tenn. A

Circle 658 on Page 19

Hybrid Junctions

Physical and electrical characteristics of precision-cast, topwall, short slot, Hybrid junctions are tabulated in Catalog HT58. How and where they are used in microwave circuits are explained. 4 pages. Microwave Development Laboratories, Inc., 92 Broad St., Babson Park 57, Wellesley, Mass. B

Circle 659 on Page 19

Dry Type Transformers

Offered as a reference guide for selecting small power and control, general and special purpose transformers, Bulletin GEA-6723 contains complete performance data, typical ratings, and prices. Application information is given on each type according to industry and market area. 24 pages. General Electric Co., Schenectady 5, N. Y. C

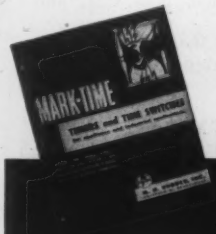
Circle 660 on Page 19

"heart"
of new super-tough alloy
prolongs timer life indefinitely...

Of far-reaching benefit to users of mechanical timers is the development of a special steel which *virtually eliminates mainspring failure* . . . a significant "first" by MARK-TIME engineers that adds extra sales features to your product at no extra cost.

Heart of the timer, this improved mainspring offers a combination of strength, durability, and corrosion resistance found in no other spring material. Tensile strength exceeds 200,000 psi. Even at abnormally high or low temperatures and in severe corrosive atmospheres the new alloy continues to demonstrate its superiority.

When the performance of your product depends on a mechanical timer, take advantage of this important engineering advance by MARK-TIME. Complete details by return mail.



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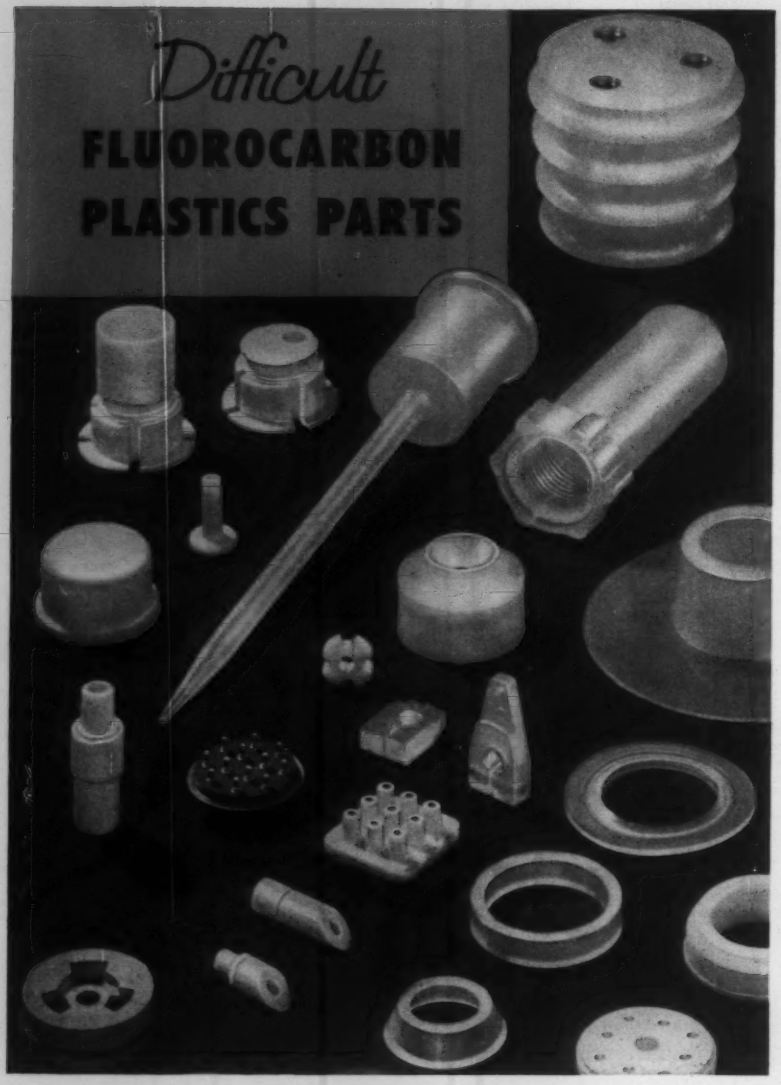
HARTFORD 6, CONNECTICUT

Rhodes is currently producing over 3,000 *different* timers. Request our revised reference catalog No. BX-233, complete with latest design and application data.

Circle 486 on Page 19



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HELPFUL LITERATURE

Steel Bars

Metal-reinforced 11 x 17-in. wall chart lists all AISI grades of cold finished steel bars. In all, 241 grades are covered, and chemical analyses are given. Table of weights is included dealing with round, square, and hexagon steel bars of thicknesses or diameters from 1/32 to 6 in. 5 pages. La Salle Steel Co., Box 6800-A, Chicago 80, Ill. J

Circle 661 on Page 19

Servo & Amplifiers

Synchro transmitters, transformers, receivers, and differential transmitters as well as Size 8 servo motors and amplifiers are described in Bulletin 501A. Motors offer high ratio of stall torque to power input, delivering 0.025 oz-in. for 3.4 w input. 4 pages. United Aircraft Corp., Norden-Ketay Dept., Commack, Long Island, N. Y. B

Circle 662 on Page 19

Dry Fluid Drives

Expanded line of Flexidyne dry fluid drives and couplings featured in Catalog A-640B covers sizes from fractional to 1000 hp. Units permit the use of smaller motors to start heavy inertial loads, afford protection against overload, assure smooth starts, and minimize slip. 24 pages. Dodge Mfg. Co., Mishawaka, Ind. J

Circle 663 on Page 19

Motors & Controls

Motor selector charts, application data, and formulas for calculating power factor are contained in Booklet B-7292 on "Synchronous Motors and Controls." It summarizes the types and features of motors and controls. 27 pages. Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa. F

Circle 664 on Page 19

Charting & Layout Tapes

Over 550 pressure-sensitive tapes for making graphs, charts, layouts, printed circuit drawings, map overlays, and slides are illustrated in enlarged booklet "Visualization Made Easier." Directions for making plant layouts and organizational flow charts are included. 32 pages. Chart-Pak, Inc., Leeds, Mass. B

Circle 665 on Page 19

Preamplifier

Both physical and electrical characteristic curves of a 3-va preamplifier are contained in Bulletin P-15. Power gain is 15,000. It can be driven by signals as small as 200 microwatts. 8 pages. Magnetics, Inc., Control Div., Box 391, Butler, Pa. F

Circle 666 on Page 19

Tubular Products

Information on types, grades, lengths, finishes, and general characteristics of small diameter stainless steel, nickel, and nickel alloy tubing and fabricated tubular parts is presented in Bulletin 12. 16 pages. J. Bishop & Co., Malvern, Pa. E

Circle 667 on Page 19

Circle 487 on Page 19

For Pin-Point Heat Control Accuracy

WEST BEND®

CHOOSES

KLIXON

Ampli-Tube

Thermostat

Control Plugs

The new control-plug appliances manufactured by West Bend Aluminum Company provide homemakers with convenient, handsomely designed controlled-heat cookers . . . automatic skillets, sauce pans, and "griddle 'n servers."

To insure pin-point temperature control, West Bend uses KLIXON Ampli-Tube Thermostats for their heat control plugs. These super-sensitive thermostats accurately control the selected heat from 150° to 425° time and time again without losing their calibration.

Today hundreds of leading appliance and original equipment manufacturers specify and use KLIXON Thermostats. These thermostats are available in both sealed and open construction in a wide variety of types and sizes. Temperature settings are custom calibrated at the factory to meet the customer's requirements.

Competent Spencer Division engineers at the factory and in the field will gladly help you make test applications of KLIXON Thermostats. Send for free literature on the KLIXON line now and get acquainted with the application possibilities on your equipment.

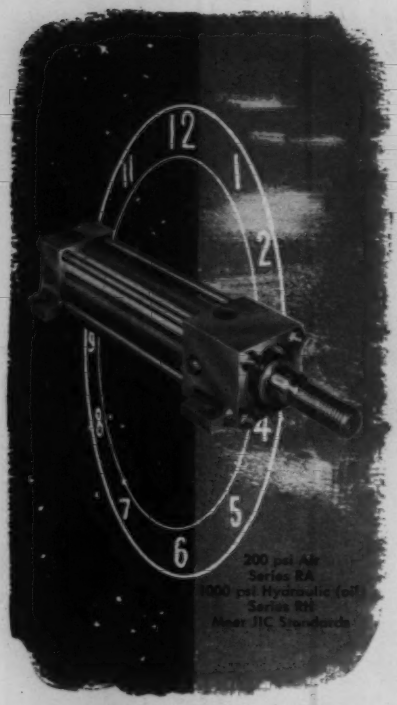
METALS & CONTROLS CORPORATION

Spencer Division

3211 Forest Street, Attleboro, Mass.

KLIXON®

Circle 488 on Page 19



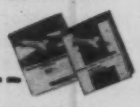
FULL 'ROUND THE CLOCK OPERATION

O-M AUTOMATION heavy-duty air and hydraulic cylinders

O-M Automation Air and Hydraulic Heavy-duty Cylinders are the result of years of research and engineering "know-how". Designed to the automotive industry's Automation Standards, they fill a definite need for outstanding durability under the most exacting demands of today's high speed automatic production.

Tested, tried and proved in actual service, these ruggedly constructed components hold untold promise for design engineers who seek to combine continuous, smooth dependable and efficient straight line motion with long life and minimum maintenance. Available in 1½" to 8" bores with front flange, rear flange, clevis, trunion or foot mount.

These and many other advanced features of O-M Automation Cylinders, that make for maximum efficiency and long life with minimum servicing, are described in our new catalogues—107 for Air Cylinders—108 for Hydraulic Cylinders. Write for your copy TODAY!



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Circle 489 on Page 19

HELPFUL LITERATURE

Hydraulic Presses

Bulletins 58-CPM and 58-CPA are descriptive of manually controlled C-frame presses in capacities to 15 tons and automatically controlled types in the same size range. Also detailed are various accessories including 6, 8, and 12-station indexing tables. 8 and 12 pages. Hydraulic Press Mfg. Co., Mount Gilead, Ohio. G

Circle 668 on Page 19

Metal & Ceramic Coatings

Basic engineering Bulletin 136A covers basic characteristics, including hardness, tensile, and bond strength of various sprayed metal and ceramic coatings. It also describes spraying equipment and automatic controls for application of these coatings. 8 pages. Metallizing Engineering Co., 1101 Prospect Ave., Westbury, Long Island, N. Y. D

Circle 669 on Page 19

High Pressure Closures

Bulletin 201.1K1 points up operating advantages of redesigned high pressure closures for feedwater heaters and other high pressure, high temperature exchangers. Closures have only four major parts, simplifying maintenance. 4 pages. American-Standard, Ross Heat Exchanger Div., Buffalo 5, N. Y. N

Circle 670 on Page 19

Thread Rolling Equipment

Features of Landmaco threading machines are highlighted in bulletin which also describes the correct ordering of Acme chasers. It points out the difference between types of Acme threads and their difference between class fits. 8 pages. Landis Machine Co., Waynesboro, Pa. E

Circle 671 on Page 19

Liquid Level Gages

The correct size and type of liquid level gage and valve for any job can be easily selected with available pocket size slide selector. It gives size numbers, visible glass, and center-to-center connections for Jerguson gages in all types and pressure groups. Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass. B

Circle 672 on Page 19

Blind Fasteners

The Huck Tau bolt, a blind application fastener, is offered in protruding head and countersink styles. Form 8-389 discusses features and lists specifications for both designs. 4 pages. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich. H

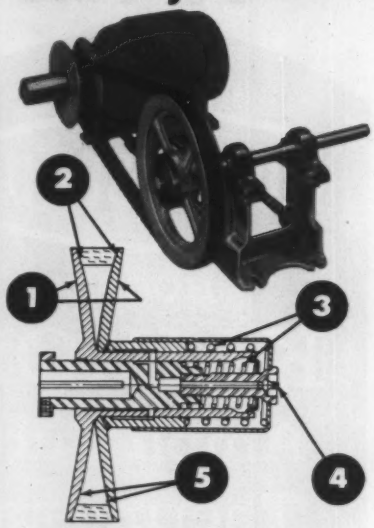
Circle 673 on Page 19

High Speed Generators

Bulletin 210-PRD-250 describes line of standard, high speed generators available from 3.75 through 62.5 kva, 50 or 60 cycle, single or three phase, in all standard voltages below 600 v. 2 pages. Electric Machinery Mfg. Co., Minneapolis 13, Minn. J

Circle 674 on Page 19

feature by feature...



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1. Both sides of the driving disk open simultaneously and equally to give constant belt alignment.
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4. Oilite bronze bushings on fractional hp. units provide life-time lubrication.
5. Curved pulley faces maintain full contact with belt sides at all times, greatly increasing overall efficiency.

Pulleys are available in a complete range of sizes, fractional to 15 hp.—full 3 to 1 ratio. Immediate delivery from stock.

Request recommendations for your application. Ask for Catalog P-58.

Lovejoy — FIRST NAME IN VARIABLE SPEED PULLEYS

LOVEJOY FLEXIBLE COUPLING CO.
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Circle 490 on Page 19

B.F.Goodrich

Lawn Boy cuts cost of fuel tank assembly with B. F. Goodrich Rivnuts®

When Lawn Boy designed their current power mower models, they decided to *suspend* the fuel tank underneath the streamlined shroud. But in order to do this they needed specialized fasteners that would fit inside the tank and provide shock-proof, fuel-tight nutplates.

They found that B. F. Goodrich Rivnuts would do this job better and more economically than any other fastener. Here's how. After the tank is formed, two holes are punched in its top. One man takes only a few seconds to upset Rivnuts in these holes. Screws are then inserted through the shroud and into the Rivnuts, attaching the tank solidly.

B.F.Goodrich Rivnuts provide firm nutplates that won't vibrate loose during operation of the mower. In addition, the special closed ends and tight clinching action of Rivnuts form a 100% fuel-tight seal.

Rivnuts can be used hundreds of ways to simplify production—give your products more eye-appeal, more sales-appeal! If you haven't already investigated their potential in your own business, why not do it now?

Send today for free Rivnut Demonstrator

Demonstrates with motion how you can use Rivnuts to fasten TO and WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MD-118, Akron, Ohio.*

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Circle 491 on Page 19

T-J spacemaker cylinder

Quality Engineered

to give quality results

with Extras . . . at No Extra Cost!

You get more—much more—when you specify and use any of T-J's complete line of Spacemaker cylinders. The Spacemaker is engineered to give you better, more accurate, and longer service—offers, exclusively, many extras . . . that are STANDARD, AT NO EXTRA COST!

Designed to eliminate tie-rods, providing greater strength . . . saves space . . . reduces manhours and costs in all push-pull-lift operations. IMMEDIATE SHIPMENT in a wide range of styles and capacities, with 64,000 combinations. Write for Bulletin SM 155-3 with complete engineering details. The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVETORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

METAL PISTON ROD SCRAPER . . . Standard at No Extra Cost!

NEW "SUPER" CUSHION FOR AIR . . . Standard at No Extra Cost!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . Standard at No Extra Cost!

ONE PIECE PISTON . . . Standard at No Extra Cost!

NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . Standard at No Extra Cost!

NO TIE-RODS TO STRETCH . . . Standard at No Extra Cost!

STREAMLINED DESIGN . . . Oil Pressure to 750 P.S.I.—air to 200 P.S.I. Standard at No Extra Cost!

FORGED SOLID STEEL HEADS . . . Standard at No Extra Cost!

Circle 492 on Page 19

Conversion Chart

Pocket-size conversion chart printed in black and red on white plastic shows the conversion of 1 sec to 1 min angles to microinches per inch, per 10 in., and per foot. It also shows the linear measure from 1 microinch to 0.005 in. in terms of minutes, seconds, and fractional seconds, per inch, per 10 in., and per foot. Engis Equipment Co., 431 S. Dearborn St., Chicago 5, Ill. J

Circle 675 on Page 19

Insulation Adhesives

Four typical insulation adhesive and sealer applications are described in Folder Z-IPF-6-58R. Adhesives and sealers are used in the heating, ventilating, building, automotive, truck, trailer, and railroad industries. Properties, application methods and coverage are listed. 4 pages. Minnesota Mining & Mfg. Co., Coatings and Sealers Div., 423 Piquette Ave., Detroit 2, Mich. H

Circle 676 on Page 19

Metal Fabricators

Machine shop, rolling mill, fabricating, welding and heat treating, and finishing facilities of this company for fabricating aluminum and stainless steel parts are pictured in brochure "Service to Industry." Typical products for the transportation field, armed forces, and the appliance and houseware fields are shown. 24 pages. Mirro Aluminum Co., Manitowoc, Wis. K

Circle 677 on Page 19

Hoses & Fittings

Complete dimensional information, engineering data, assembly instructions, and other facts about Aeroquip medium and high pressure hoses of Teflon and "super gem" fittings for aircraft applications are provided in Catalog 103. Instructions for ordering hoses and fittings of special length and design are also provided. 66 pages. Aeroquip Corp., Jackson, Mich. H

Circle 678 on Page 19

Dry Batteries

Aid to product design engineers in selecting the proper dry batteries for numerous applications is provided by "Engineering Manual." Space allowance, discharge considerations, terminal connections, and other factors are detailed. Batteries covered range from 1½ to 510 v and weigh from 0.013 to 16 lb. 100 pages. Request on company letterhead from Burgess Battery Co., Freeport, Ill. K

Electric Conductors

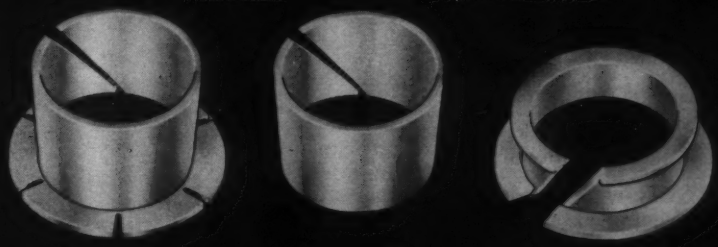
Logarithmic conductor slide rule is an aid in selecting dimensions of aluminum foil or sheet for use in strip-wound electrical coils. It converts from standard wire sizes in copper or aluminum to an equivalent aluminum strip conductor. Weight and electrical resistance data are given. Request directly from Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa. F

Circle 493 on Page 19→

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS®

of smooth, tough DuPont NYLON



Low Cost FLANGED Nyliner | Low Cost SLEEVE Nyliner | Low Cost DOUBLE-FLANGE Nyliner

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• COST LESS to BUY*
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Additional Benefits:

- CLOSE FIT
- LONGER LIFE
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- SILENT OPERATION
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NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

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Also—Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting

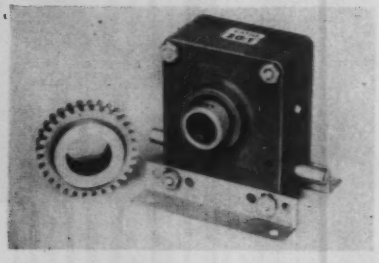
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Speed Reducers

fractional-horsepower units have aluminum gears

SW-1 speed reducers incorporate aluminum driven worm gears of bearing-type alloy which provide up to three times greater torque capacity than molded nylon types. Reducers have ratios of 3½:1 to 60:1, with solid or hollow output shaft. Complete unit, with molded nylon glass fiber case and machined steel worm-gear input shaft weighs less than 21 oz and measures 3¾ in.



high x 3⅞ in. wide x 3⅛ in. deep. Applications include use in business machines, appliances, control devices, servomechanisms, and other power-transmission systems. **Rampe Mfg. Co.**, 14915 Woodworth Ave., Cleveland 10, Ohio. G

Circle 679 on Page 19

Digital Place Marker

provides repeat settings to 1/100-turn accuracy

New digital place marker provides precision setting, adjustment, and relocation of rotating adjustment shafts of multiturn potentiometers and variable capacitors. Knob of turns-counter assembly mounts on component adjusting shaft and operates both shaft and counter. Counter gives continuous direct digital reading of shaft position to 1/100-turn accuracy. The three-digit counter provides direct readings to 999 or ten complete clockwise revolutions of shaft. Standard units are furnished for ⅛ or ¼-in. component shaft diam. Numerals are white on black wheels. **Production Instruments Div., General Controls Co.**, 8062F McCormick Blvd., Skokie, Ill. J

Circle 680 on Page 19

Miniature Flowmeter

for maximum pressure of 100 psi

Miniature flowmeter is used for applications where a simple device is required to show if fluid flow is taking place, as well as to meter quantity of fluid. Rate of flow is measured by movement of a variable-position orifice, clearly visible through an opening sealed with high-pressure glass tube. Adjacent scale is calibrated in units of 0 to 10, and flow rate is determined with a calibration chart. Meter is suitable for maximum pressure of 100 psi. Capacity ranges are from ¼ to 4 gpm. Flowmeter is easily inserted into a ¼-in. IPS pipe line, and can be mounted in tight corners or inaccessible spots. **Henry G. Dietz Co. Inc.**, 12-16 Astoria Blvd., Long Island City 2, N. Y. D

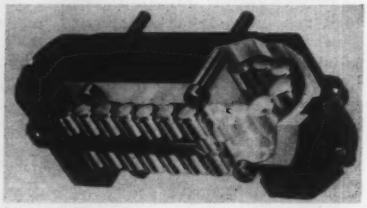
Circle 681 on Page 19

Antifriction Way Bearing

has simplified mounting method

Four through-holes accept socket-head cap screws to provide a simplified mounting method for Tychoway antifriction way bearing. Method gives unlimited travel, constant accuracy, and reduction of feed power. Center-guided roller eliminates roller skew, and minimizes bearing wear and lubrication requirements. All working parts are 52100 bearing steel to provide long life and operational accuracy. The recirculation bearing is available in loads from 2000 to 32,000 lb in standard precision, or with matched sets for extremely accurate applications in precision machines. **Tycho Mfg. Co.**, 561 Hillgrove Ave., La Grange, Ill. I

Circle 682 on Page 19



Lever-Action Switch

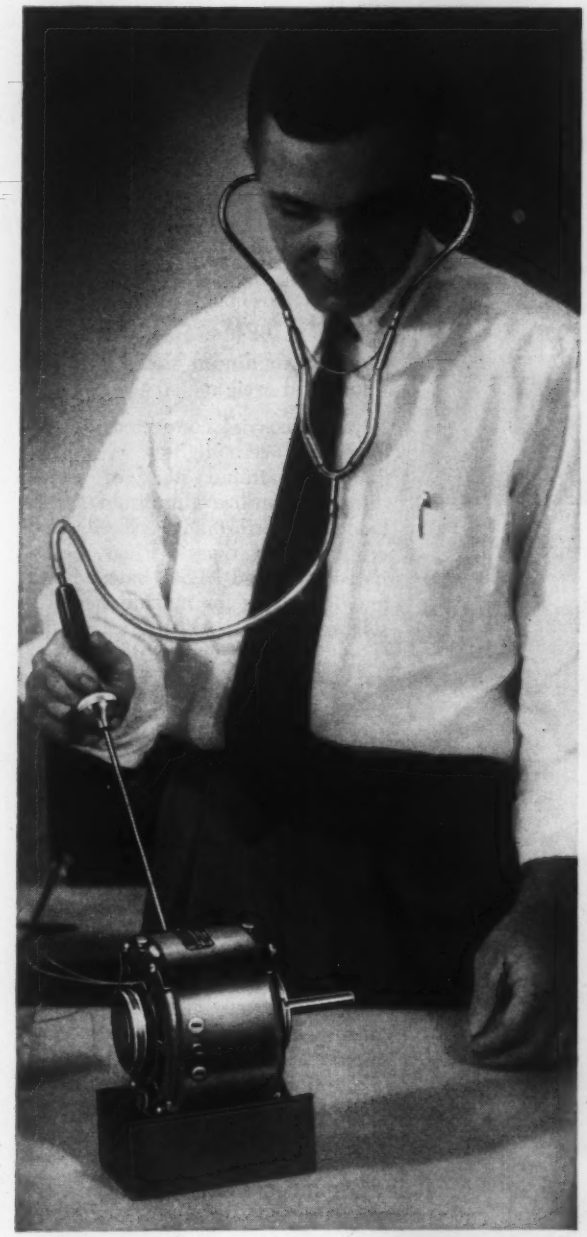
requires one-fourth normal behind-panel depth

Series 12000 Lev-R switch requires only one-fourth the depth of conventional key switches behind panel. It is available in two and three-position types, locking and nonlocking, and three-position locking one side and nonlock other side. Relatively

Highest Quality and Most Economical . . .

Quietest Direct Drive Blower Motor

Redmond's New Design Reduces Blower Vibration to One-Fifth that of units using Conventional Shaded-Pole Motors

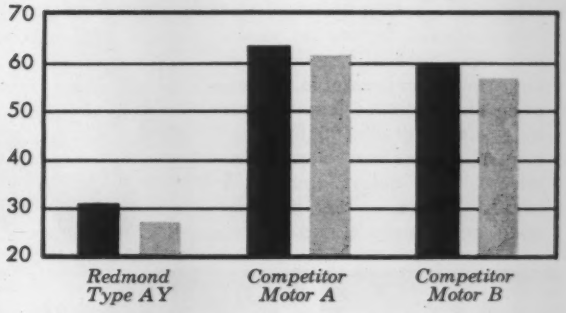


Place a mechanic's stethoscope on the end cap and you can easily hear the difference between the newly-designed Redmond Type AY and motors of conventional design. Try it on a Redmond 1/6 hp—the noise level is about that of a 1/35 hp motor of conventional design.

Apply vibration tests and you will be quick to agree that here is the quietest direct-drive blower motor available. The AY Tri-Flux motor is designed and manufactured in every way to give years of trouble-free service and whisper-quiet operation. The positive oil system provides force-feed lubrication. Recirculating the oil assures maximum bearing life.

The graph shows vibration test results on the new Redmond design and two competitive motors. These tests were made with the best vibration testing equipment available. The solid black bar shows vibration on the motor end cap; the gray bar shows vibration on the blower housing. The graph is decibel readings on 120 cycles, since the 120 cycle frequency is the one that is the basic source of nearly all noise problems. Reduction of vibration is a logarithmic function—the reduction of vibration in the Redmond motor to 33 decibels reduces noise to only 1/5th that of conventional motors.

The new AY is ideal for a wide variety of applications requiring a whisper-quiet, economical, high-quality motor. Contact us at Owosso, Michigan, and we will have the Redmond sales engineer in your district call you at once.



The Standard of Dependability

CC Redmond COMPANY, Inc.

Subsidiary of CONTROLS COMPANY of AMERICA

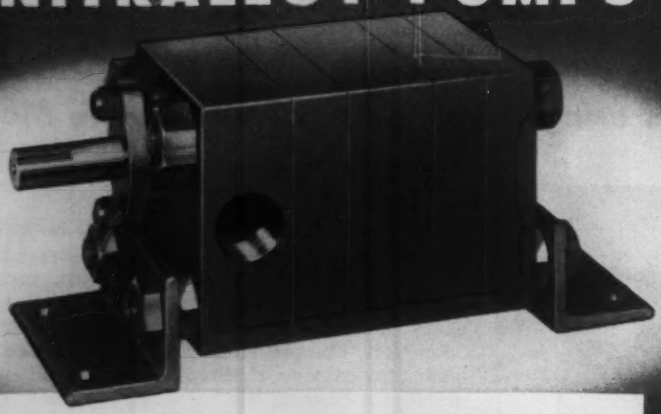
OWOSSO, MICHIGAN

THE BIG NAME IN SMALL MOTORS

REDMOND

Circle 494 on Page 19

NORTHERN
NITRALLOY PUMPS



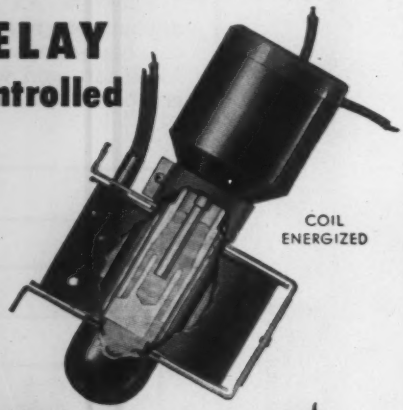
Unique block construction permits selection from a wide choice of metals for virtually any pumping need. Proven in thousands of installations . . . backed by 50 years of engineering and production experience. Unexcelled for precision manufacture, accurate assembly and dependable, long-life operation. Pressures to 2,000 PSI. Capacities from ¼ to 146 GPM. *Write for free catalog and engineering data.*

NORTHERN ORDNANCE, INCORPORATED
Subsidiary
NORTHERN PUMP COMPANY
MINNEAPOLIS 21, MINN.

Circle 495 on Page 19

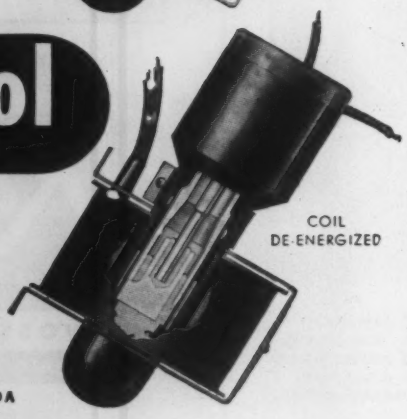
The TIMER RELAY
that handles all controlled timing problems . . .

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.



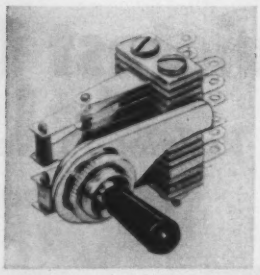
Durakool
STEEL MERCURY TIMERS

★ No false contacts
★ Non sticking
★ Practically "fail safe"
★ Low cost timer



See telephone directory for local distributor, or write.
DURAKOOL, INC.
ELKHART, INDIANA, U. S. A.
700 WESTON RD., TORONTO 9, CANADA

Circle 496 on Page 19



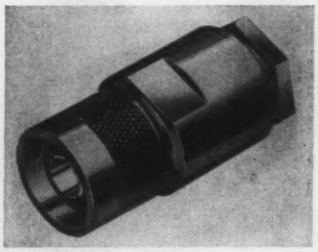
long springs without "forms" at point of flexing provide suitable spring action for long life. Springs are assembled into a stack assembly and insulated from each other. Silver contacts rated at 3 amp (300 w max) noninductive load are standard. **Switchcraft Inc.**, 5555 N. Elston Ave., Chicago 30, Ill. I

Circle 683 on Page 19

Coaxial Plugs

utilize aluminum shells for light weight

New RF coaxial connectors are 35 to 40 per cent lighter in weight than comparable standard units, since they utilize aluminum shells. Electrical performance exceeds that of brass-shell types. Plugs, designated ALN and ALSC, have a black anodic coating for maximum corrosion resistance. ALN series accom-



modates RG, Foamflex, and Raytherm coaxial cables, and ALSC accepts only RG cable. Both types have improved clamping mechanism which does not distort cable dielectric. **Cannon Electric Co.**, 3208 Humboldt St., Los Angeles 31, Calif. L

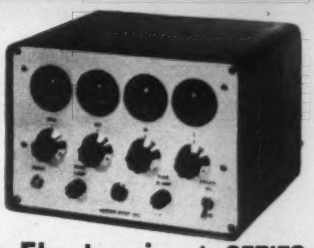
Circle 684 on Page 19

Pneumatic Muffler

incorporates improved internal resonator

New Atomuffler incorporates a redesigned internal resonator that provides efficient silencing of noise re-

NEW Veeder-Root Counters



New Electronic Predetermining Counters

SERIES 1604

These counters are ideal for batch control, sequential predetermining, or accurate length control in such applications as packaging, coil winding, slittling, stacking and material handling.

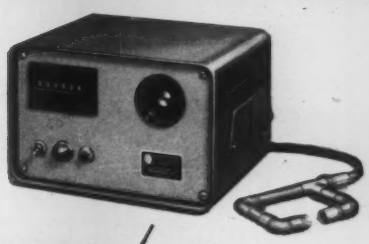
A versatile group of transistorized electronic predetermining counters designed particularly for industrial applications. These units will operate at speeds up to 5,000 counts per second, with automatic recycling at speeds up to 1,000 counts per second. A photohead to actuate the counter can be designed to fit specific applications.

Units can be easily operated by non-technical personnel. The preset quantity can be established quickly at any point within the range of the counter by means of the large selector knobs. Any number of decades can be furnished.

Dual sets of presetting controls for sequential predetermining, or accurate length control in such applications can be furnished on request.

This is your complete package for predetermining counting at high speeds.

For complete details on these units, write today!



Count-PAK

SERIES 1681

Complete electronic counting package for use where high speed, long life and instant reset are required. Highly suitable for high speed direct counting applications such as can and bottle counting or case or piece counting on conveyor lines.

Consists of glow-transfer cold-cathode counting tube and high speed magnetic counter, coupled with transistorized circuits. Photohead designed to your application.

The use of transistors means that heat has been eliminated and no warm up time is required. Unit is completely enclosed in an attractive industrial case to insure long, trouble-free life. Use of an electronic decade increases the life of the electro-mechanical counter and makes the unit ideal for continuous rugged operation.

Write for complete specifications and prices today!

NEW SERIES 1522

High-Speed Predetermining Counter

Ideal for high-speed counting requirements such as coil winding, textile spinning frames, and other predetermining counter requirements.

Instant quick-lever reset, plus quick and easy setting of the predetermined number are outstanding features of this counter. Measures approximately 2.6″ wide, 5″ long, 2.8″ high. Speeds up to 6,000 RPM or 8,000 CPM are maximums recommended.

Easily preset to the required number of pieces or performance-units, the counter subtracts to zero. Resetting returns wheels to original preset number. This new counter meets standard U. S. electrical requirements (JIC Codes) . . . and is available with either electrical switch or mechanical stop. Also available without the predetermining feature, as a high speed reset revolution counter.

Also available as a high-speed revolution counter without predetermining feature.

Write for complete information today!

SERIES 1591

Electro-Magnetic Counter

These new compact panel-mounted high speed counters are ideal for D.C. applications requiring accuracy, long life at high speeds and small panel presentation. Counters are suitable for industrial data processing, laboratory and scientific or instrument applications. Available with four or six figures with remote electrical or manual (push button) reset. 3,000 counts per minute recommended speed.

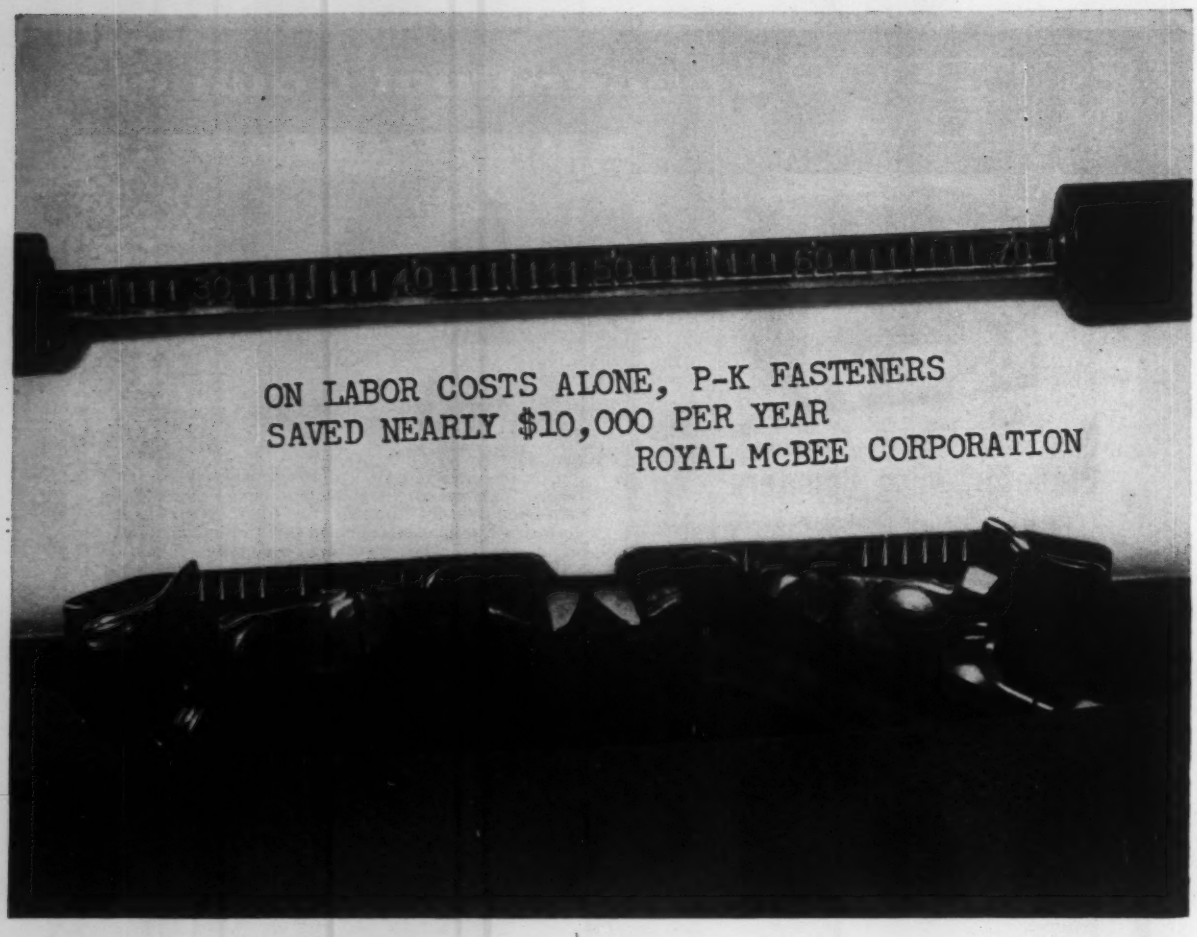
Counters can be connected in series with any device having a contact arrangement. For optimum operation, 60% contact time is required.

Panel Area: 4-figure Counter — 1.7″ x 2.1″
6-figure Counter — 1.7″ x 2.8″

Available for 6, 12, 24, 48 and 115 volts D.C. operation. For A.C. operation suitable electrical components must be added externally. Reset voltages available are 6, 12, 24, 48, 115 and 230.

Write for complete specifications today!

Veeder-Root
INCORPORATED
HARTFORD 2, CONNECTICUT
Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago • New York
Los Angeles • San Francisco • Montreal • Offices and Agents in Principal Cities



"For fastenings in steel, in plastics, and in die cast aluminum, we switched to P-K Self-tapping Screws and save time and money in every case," says Henry Teller, Supervisor of Assembly Standards, *Royal Typewriter plants of the Royal McBee Corporation.*

"At our Hartford plant alone, where more than 500,000 typewriters per year are assembled, we use P-K Self-tapping Screws for speedy, dependable fastening of Tenite plastic space bars, space bar stops and buffers, top covers and base masks, cover hinges and latches and many other assembly operations.

"Waste is ended, too. For example, just a bit too much pressure with air guns or the slightest angle when inserting ordinary screws, often caused stripping of the hole and a discarded space bar. Now, with P-K Screws, production is uninterrupted—rejections practically eliminated."

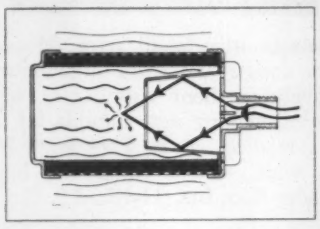
Royal McBee Corporation's experience with Parker-Kalon Self-tapping Screws is typical of literally thousands of similar cases. A P-K® Field Engineer will be glad to discuss your fastening applications—show you how you, too, can effect real savings.

PARKER-KALON® Self-tapping Screws

Sold everywhere through leading Industrial Supply Distributors

PARKER-KALON DIVISION, *General American Transportation Corporation, Clifton, New Jersey*

sulting from air operation. Speeding air leaving exhaust port is broken up by internal deflector. Resulting scattered waves are parabolically reflected into many opposing high-velocity forces. Collision of focused forces cancels rushing air before it becomes noise. Patented radial disseminator permits lowered-



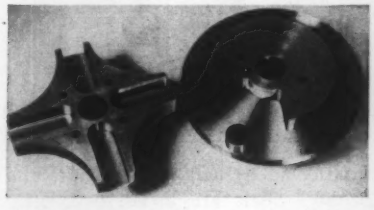
velocity exhaust air to drift into atmosphere quietly. Unit diffuses escaping air at a ratio of 60:1. **Allied Witan Co. Inc.**, 12500 Bellaire Rd., Cleveland 35, Ohio. F

Circle 685 on Page 19

Geneva Drives

now with up to 24 indexing stations

Standard Geneva drives are available with 3 to 24 indexing stations for shaft center distances from 3 to 6 in. in ¼-in. increments. Wide variety of hub and bore diameters is offered. High-quality steel wheels are furnished, with ductile iron or bronze driving wheels. Balanced



drive assures indexing, smooth performance, and long life. **Geneva-matic Engineering Corp.**, P. O. Box 10386, Tampa 9, Fla. O

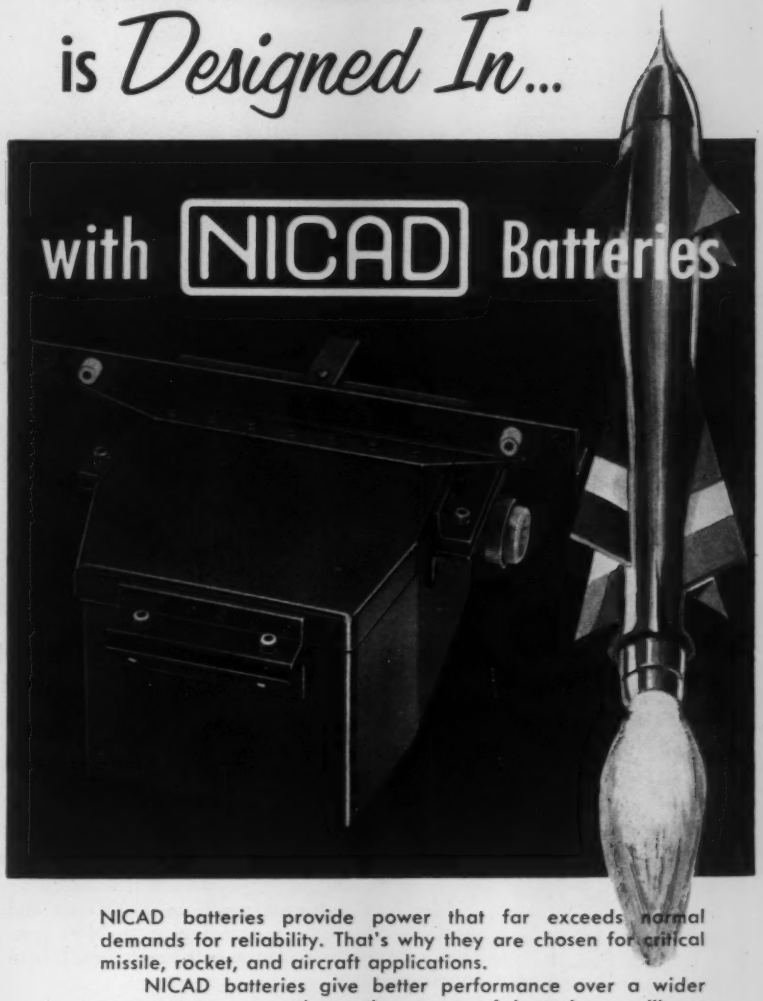
Circle 686 on Page 19

High-Speed Counter

accepts speeds to 6000 rpm or 8000 counts per minute

Model 1523 high-speed, quick-reset, geared-revolution counter is designed for general-purpose work where speed and ease of reset are important. It accepts speeds up to 6000 rpm or 8000 counts per minute. Flick of lever through a 60-deg arc

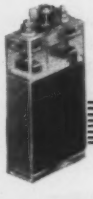
Proven Reliability is *Designed In...*



NICAD batteries provide power that far exceeds normal demands for reliability. That's why they are chosen for critical missile, rocket, and aircraft applications.

NICAD batteries give better performance over a wider temperature range than other types of batteries... will not freeze in any state of charge... give off no corrosive fumes. Their compact size—smaller and lighter than conventional batteries—conserves the space so valuable in the confined power systems of missiles and aircraft. Rugged construction makes them capable of withstanding severe shocks and vibration. And their long life and virtually maintenance-free operation give long-term economy unmatched by any other type of battery.

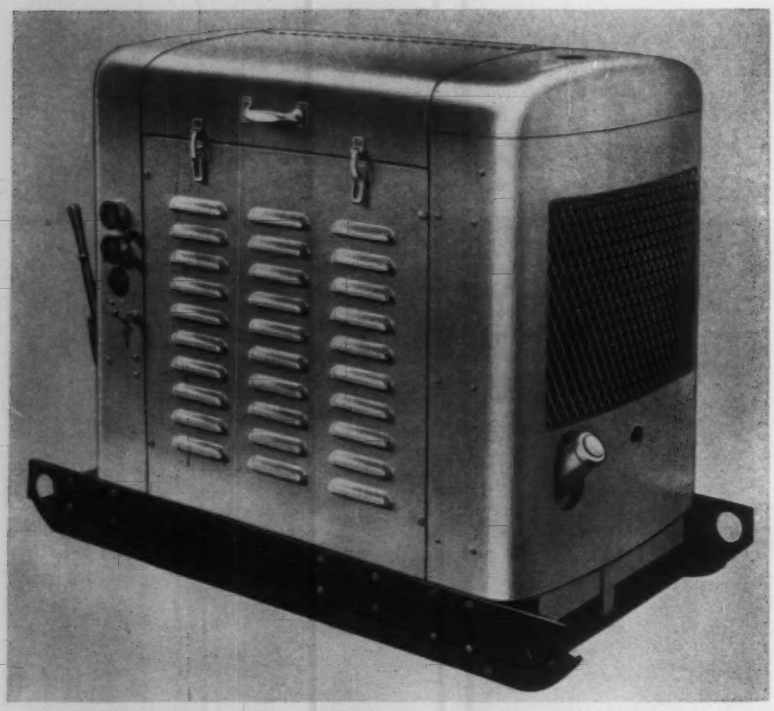
Find out how you can design exceptionally reliable and economical power into your company's new or redesigned products. Request detailed information. ***NICAD Division, Gould-National Batteries, Inc.***, Easthampton, Mass. Offices in New York, Chicago, San Francisco.



NICAD

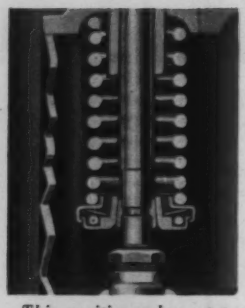
NICKEL CADMIUM ALKALINE STORAGE BATTERIES

Circle 499 on Page 19



The 'Jeep'-6 power unit is a complete package from radiator to SAE bell housing.

New 'Jeep'®-6 rugged power unit

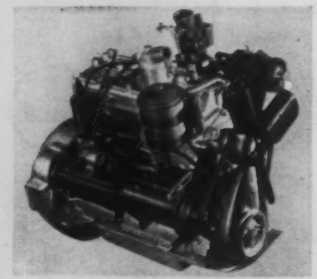


This positive valve rotator is supplied as one of many extra features in 'Jeep' engines...at no extra cost!

Heavy duty — high torque engine for tough power uses

The 'Jeep'-6 torque peaks at 1200 rpm and loses less than 8% in speeding up to 2600 rpm. This means extra performance under heavy load conditions.

Unusual quality features of pistons, valves and bearings mean extra hours of dependability. If you want tough engines... at reasonable cost, write immediately for complete information.



'Jeep'-4's offer an unusual combination of power plus economy.

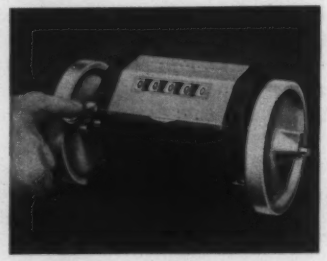
One of the 'Jeep'-4's may suit your needs best...

Two models available . . . can often replace a low powered "six" yet with no loss of smooth performance. Write today!

KAISER WILLYS MOTORS

WILLYS MOTORS, INC.

Industrial Engine Dept., Toledo, Ohio



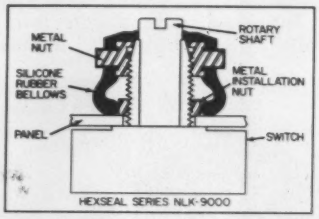
resets counter to all zeros. Modern case design and extra-large figures provide excellent visibility at wide angles, making unit suitable for in-line reading. It is 5 in. long, 2⅝ in. wide, and 2 13/16 in. high. Veeder-Root Inc., Hartford 2, Conn. B

Circle 687 on Page 19

High-Pressure Shaft Seal

for locking-type rotary devices

Hexseal Series NCK-9000 is a high-pressure shaft seal for locking-type potentiometers and variable capacitors. It maintains seal in both locked and unlocked positions. Basic design is a one-piece silicone-rubber bellows molded to a metal nut. Bellows seals against panel and an inwardly protruding O-rib seals against rotary shaft. Materials are



unaffected by salt water, acids, and ozone. Seals are useful over temperature range of − 160 to 500 F and are recommended for use in pressurized and environmentalized equipment. **Automatic & Precision Mfg. Co.**, 252 Hawthorne Ave., Yonkers, N. Y. D

Circle 688 on Page 19

Bronze Bars

standard and tubular units are 105 in. long

Solid and tubular bronze bars are now furnished in 105-in. lengths which can be cut in a variety of lengths without waste. Use of continuous casting method provides

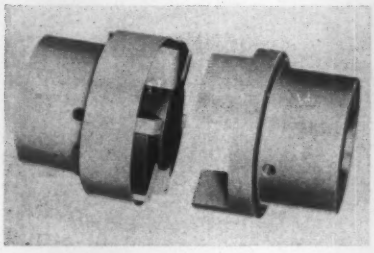
more uniform distribution of lead and other elements which improves machinability, provides greater tensile, yield, impact, and fatigue properties. Continucast 105-in. bars are available in 21 sizes of solid bars from ½ to 3 in. diam, and in 118 sizes of tubular bars from ½ to 2½ in. ID and from 1 to 3 in. OD. **Johnson Bronze Co.**, New Castle, Pa. G

Circle 689 on Page 19

Flexible Coupling

for heavy-duty use

Model GH flexible coupling is for heavy-duty use in sizes from 35 to 700 hp at 1800 rpm. It has removable inserts held in place by a steel collar to provide easy inspection or replacement of inserts. Unit is



available for shafts up to 5½ in. diam. It is also supplied with tapered bores to accommodate QD bushings. **Gerbing Mfg. Corp.**, Northbrook, Ill. J

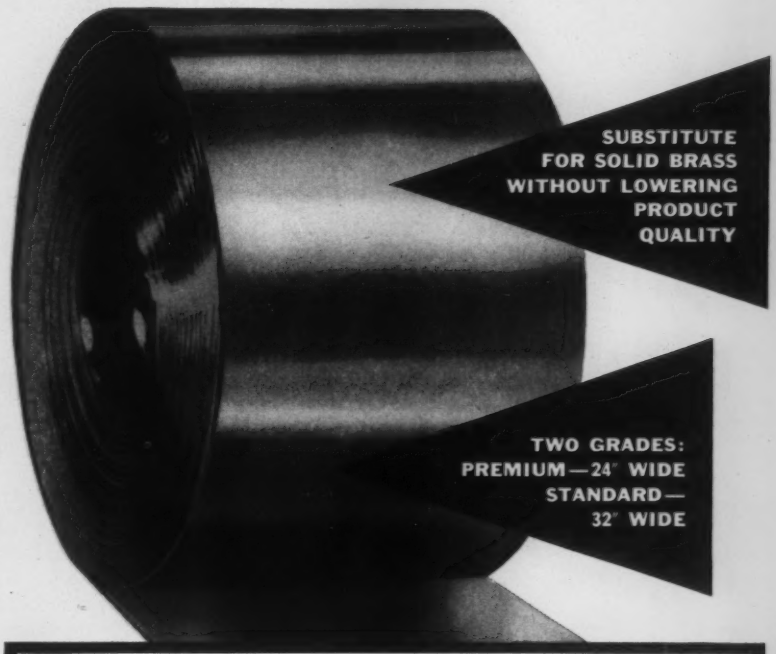
Circle 690 on Page 19

Textured Vinyl Finish

for parts of glass fiber and phenolic moldings

Unichrome coating B-64 is up to five times more resistant to abrasion than standard textured alkyd urea enamels, and is highly resistant to corrosives. Available in an unlimited number of colors, finish can be applied in various degrees of sheen in pebble texture or smooth finish. It provides a hard, flexible finish which will not mar or crack, withstands perspiration, ink, beverages, commercial cleaning preparations, and other acid or alkaline corrosives. Material has advantages as a finish for parts made of glass fiber polyester resin and phenolic moldings since baking temperatures are lower than required for vinyl plastisols and

NEW PRE-FINISHED BRASS-STEEL SAVES 25% OR MORE ON MATERIAL COSTS



Combines the Decorative Properties of Brass With the Economy of Steel

Where the only BRASS you *need* is the brass you *see*, save 25 percent or more on material costs, reduce production steps with brass-plated steel. This way, the only BRASS you pay for is the substantial brass coating you *really need*. Big 32" wide coils — the widest ever made — in Standard grade, for utility or decorative uses; 24" wide in Premium grade, our finest quality — an economical substitute for pure brass for many applications. Both grades are sealed with BAKEKOTE, a baked resin film. Mar-Not protective coating protects the pre-finished surface during fabrication. Big 24" and 32" wide coils and sheets — bright and satin finishes and crimps. Also stripes in sheets, only.

UNPOLISHED — For those parts designed beyond the fabrication limits of our regular pre-finished material, consider *unpolished* Brass-Steel. Excellent for post-finishing work or for applications where high surface finish is not required.

Write For More Information

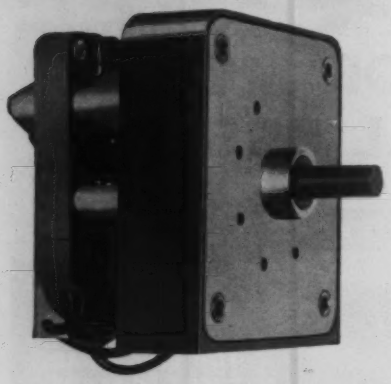
NICKELOID METALS SINCE 1898

AMERICAN NICKELOID COMPANY
PERU 8, ILLINOIS

Mills: Peru, Ill. and Walnutport, Pa. — Sales Offices Throughout the U.S.A.

Circle 501 on Page 19

put HEINZE in your designs



NEW HEINZE GEARMOTORS with choice of Drives–Speeds

Powerful, compact, quiet . . . Heinze Gearmotors offer four sub-fractional horsepower driving motors: 2 and 4 pole induction; universal; reversing. Speeds range from approximately 700 rpm down to 1 revolution in eight minutes. Geartrain may be enclosed or open, base or panel mounted. Gears, pinions and shafts are made from finely tempered and hardened steel. Felt oil reservoir in geartrain guards against oil leakage. Oil-impregnated bronze bearings insure long, trouble-free operation.

Send coupon for complete technical data

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
Sub-Fractional Horsepower Motors and Blowers

HEINZE ELECTRIC COMPANY, Dep't D
685 Lawrence Street, Lowell, Mass.

Please send me literature and prices on Heinze Gearmotors.

Name & Title.....

Company.....

Street & No.....

City & State.....

Circle 502 on Page 19

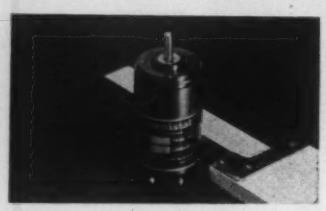
organosols. Finish is recommended for such products as business machines, electronic equipment, metal furniture, and transportation equipment. **Metal & Thermit Corp.**, Rahway, N. J. D

Circle 691 on Page 19

Miniature Potentiometer

has 0.05 per cent terminal linearity

Series 4 Vernistat potentiometer is a size 11 component with diameter of 1.062 in. and weight of only 2 oz. It is available with maximum output impedances of 200, 100, and



40 ohms, combined with high input impedance and low output quadrature. Minimum output voltage increment (resolution) is 0.01 per cent, and terminal linearity is 0.05 per cent. Applications are found in servo systems, control systems, and analog computers. **Perkin-Elmer Corp.**, Danbury Rd., Norwalk, Conn. B

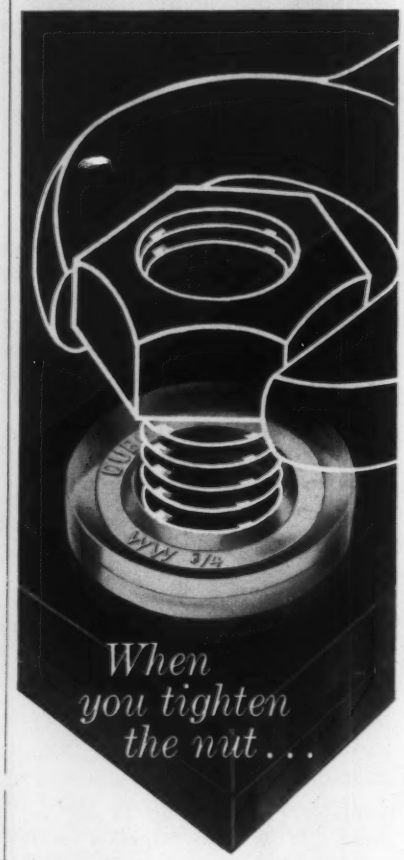
Circle 692 on Page 19

Hydraulic Power Check

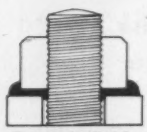
checks thrust loads to 1500 lb

Model 1500 in-line, single-acting, hydraulic power check is designed to provide precise feed control of air cylinders and other machine feed components. Unit checks thrust loads up to 1500 lb and provides checking action on either forward or reverse stroke and unrestricted movement on opposite stroke. It prevents chatter and flutter when applied to pneumatic cylinders, and provides uniform feed that is unaffected by variations

This new lock and seal washer is just plain **REVOLUTIONARY...**



NYLOGRIP Dubo Lockwasher locks and seals it-instantly!



Patents Applied For

The new NYLOGRIP Dubo Lockwasher is made of a special, cold-flow plastic called Nylon 6. When the nut is tightened, the washer "flows" — its inner diameter grips into the threads of the nut and bolt, to seal this junction against leakage, while the outer diameter flows over the outer edges of the nut, seals and locks it . . . so tight neither shock nor vibration can budge it! The Dubo Lockwasher can be used time and again without the slightest loss of holding power. And, because it's symmetrical and has no threaded parts, you couldn't fit one incorrectly if you tried.

PLUS FEATURES: excellent electrical properties . . . exceptional wear resistance . . . good shock absorption . . . resists corrosion, chemicals . . . non-flammable . . . high flexural strength.

PLUS USES: The excellent electrical characteristics of NYLOGRIP Dubo Lockwashers make them ideal for electrical insulation, or to help control electrolytic corrosion between dissimilar metals.

YOU'LL WANT COMPLETE TECHNICAL INFORMATION.

Write today to:

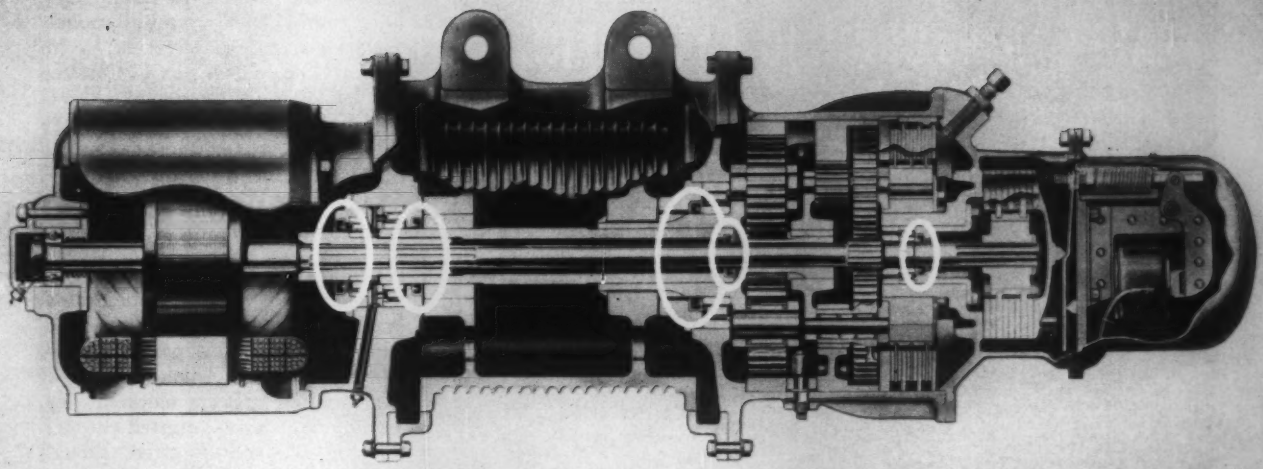
NYLOGRIP PRODUCTS

445 Watertown St., Newton, Mass.-BI 4-0960

Non Metallic Fastenings of all types.

Circle 503 on Page 19

MORE ABOUT THE GARLOCK **2,000**



General-purpose KLOZURE Oil Seals (Model 63 cutaway right) afford complete protection at important bearing locations (circled above) on the Shepard-Niles "Liftabout" Hoist.

Garlock Klozure* Oil Seals

assure durable, dependable performance on tough sealing jobs

Friction and bearing wear, hazardous to any industry, are especially harmful in materials handling. That's why Shepard-Niles and other leading crane and hoist manufacturers specify Garlock KLOZURE Oil Seals for complete bearing protection. Shepard-Niles "Liftabout" is typical of how Garlock KLOZURES not only exclude dust and foreign matter from bearings but also retain the important lubrication—both of which add to greater dependability during rugged hoist operation.

Designing Garlock KLOZURES into your equipment protects bearings with oil seals that are durable, economical, and easy to replace. Garlock KLOZURES can be applied on low, medium, or high speed service. Whether your application is general-purpose in nature, or there's a specific job to be done, Garlock has a KLOZURE design for you.

KLOZURES are another of the Garlock 2,000 . . . two thousand types of packings, gaskets, and seals for every need. The only complete line. It's one reason you get unbiased recommendations from your Garlock representative.

Call him or write for KLOZURE Catalog 20.

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For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

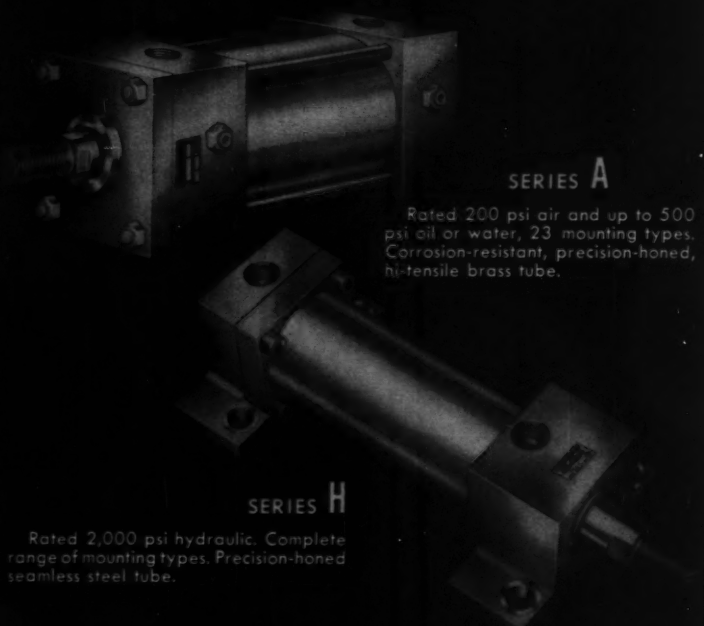
GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products.

Circle 504 on Page 19

for increased production . . .
minimum down-time . . .
lower costs . . . specify

AIR and HYDRAULIC CYLINDERS



SERIES A

Rated 200 psi air and up to 500 psi oil or water, 23 mounting types. Corrosion-resistant, precision-honed, hi-tensile brass tube.

SERIES H

Rated 2,000 psi hydraulic. Complete range of mounting types. Precision-honed seamless steel tube.

- floating cushions—uniform cushioning—long life—fully adjustable
- easily removed cartridge-type rod seals with integral rod wiper
- choice of rod sizes for all applications—rods heat-treated and hard chrome plated for resistance to nicking and scoring
- steel heads and end plates for strength and positive alignment
- all ferrous parts rust-proofed

Before you buy any cylinder, consider the quality design and construction features of S-P air and hydraulic cylinders—features that will assure dependable performance . . . long service life . . . minimum down-time . . . lowest end cost.

What's your cylinder problem? We'd like to help you solve it—a phone call will bring our representative on the double. Prompt deliveries, too. The S-P Manufacturing Corporation, 30201 Aurora Road, Solon, Ohio.

for speed and performance

Representatives in principal cities. Phone or write for Catalogs No. 110B (Series A) and No. 104A (Series H).

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NON-ROTATING AIR AND HYDRAULIC CYLINDERS • ROTATING AIR AND HYDRAULIC CYLINDERS • POWER CHUCKS • COLLET AND DRILL PRESS CHUCKS • VALVES, ACCESSORIES

A BASSETT COMPANY • IN GREATER CLEVELAND • ESTABLISHED 1916

AA-7487

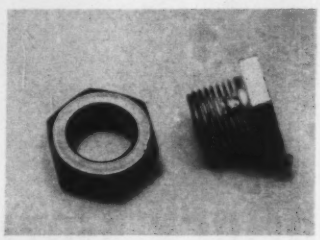
in power thrust. The self-contained unit consists of an oil-filled, spring-loaded cylinder, checking piston and rod, and sensitive needle-valve control. Unit is available in six sizes with strokes from 2 to 12 in. Cylinder bore is 1.385 in. on all models and piston rod diameter is ½ in. **Appco Corp.**, P. O. Box 6, Olmsted Falls, Cleveland, Ohio. G

Circle 693 on Page 19

Fastener and Bushing

holds cable together and fastens it to panel or wall

New bushing and compression-type fastener holds tubing, pipe, cable, or wire immovable, and simultaneously fastens it to a panel or wall. Threaded hollow bolt which is heat-treated has an elevated key. Tubing or cable is inserted through bushing, which is inserted through panel or wall. When nut is screwed on, key is depressed, causing compressive action on tube or cable and holding it in place. Adjustment of throw gives load pressures of any compressive force. Variety of sizes is available. **Barr Machine & Tool Div., Denver Metals & Chemicals Corp.**, 2130 South Platte River Dr., Denver 23, Colo. K



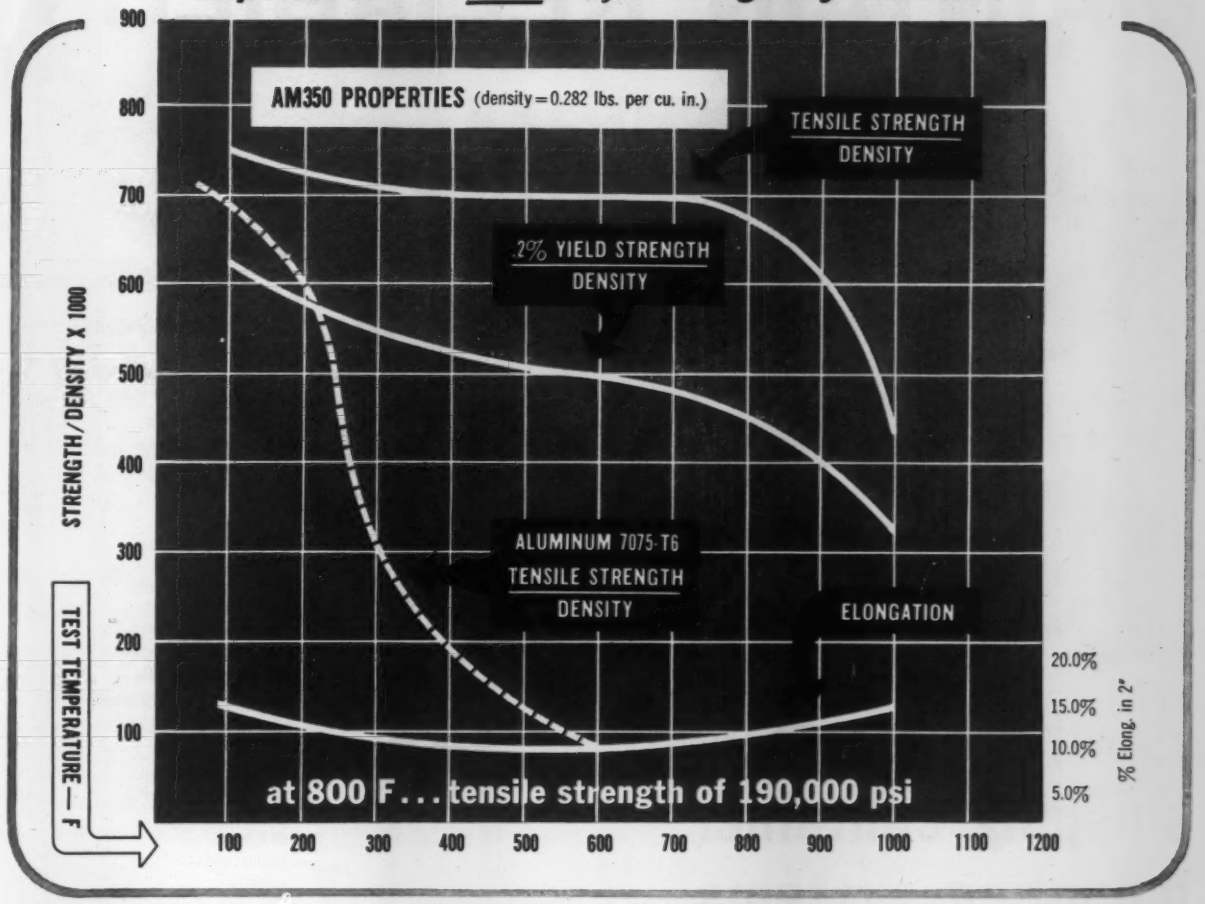
Circle 694 on Page 19

Multiple-Plate Clutches

for machine tools and transmissions

Model DO and DOC wet-type, multipe-plate clutches are built to run in oil and are actuated by oil pressure of 100 to 300 psi, depending on application. They are designed for machine tools, transmissions, and similar applications. Model DOC, shown, has an integral oil collector; ¼-in. NPTF line connected to stationary collector makes clutch ready for use. Model DO omits around-the-shaft collector, shortening the unit somewhat. Both

Experience**—the extra alloy in **Allegheny Stainless



Here are the facts on AM350 and AM355, Allegheny Ludlum's precipitation hardening stainless steels

A unique combination of highly desirable properties is the usual description of Allegheny Stainless AM350 and AM355 Steels. They combine high strength at both room and elevated temperatures, excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

They are proving the answer to many problems of the air age. Airframe and other structural parts, pressure tanks, power plant components, high pressure ducting, etc. are all natural missile and supersonic aircraft applications for AM350 and AM355.

Availability: AM350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM355, best suited for heavier sections, is available in forgings, forging billets, plate, bar and wire.

Corrosion resistant: Being stainless steels, these alloys resist corrosion and oxidation. Compared to the older, more familiar stainless grades, their corrosion rating is better than the hardenable grades (chromium martensitic) but generally less than the old corrosion resistant standbys, the 18 and 8's. Stress corrosion is resisted at much higher hardness levels than with martensitic stainless.

Simple heat treatment: High strength is developed by two methods, both involving less than ordinary temperatures and minimizing oxidation and distortion problems. The most popular, and one that develops slightly better properties, is the Allegheny Ludlum developed sub-zero cooling and tempering (SCT condition). The material is held at minus 100 F for 3 hrs plus 3 hrs at 850 F. Alternate method is Double Aged (DA): 2 hrs at 1375 F plus 2 hrs at 850 F.

Easy fabrication: AM350 and AM355 can be spun, drawn, formed, machined and welded using similar procedures as with the 18-8 stainless types. In the hardened condition (SCT & DA) some forming may be done . . . 180 degree bend over a 3T radius pin. Also it can be dimpled in the hard condition to insure accurate fit-up.

For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM350 and AM355." ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*** Address Dept. MD-11.

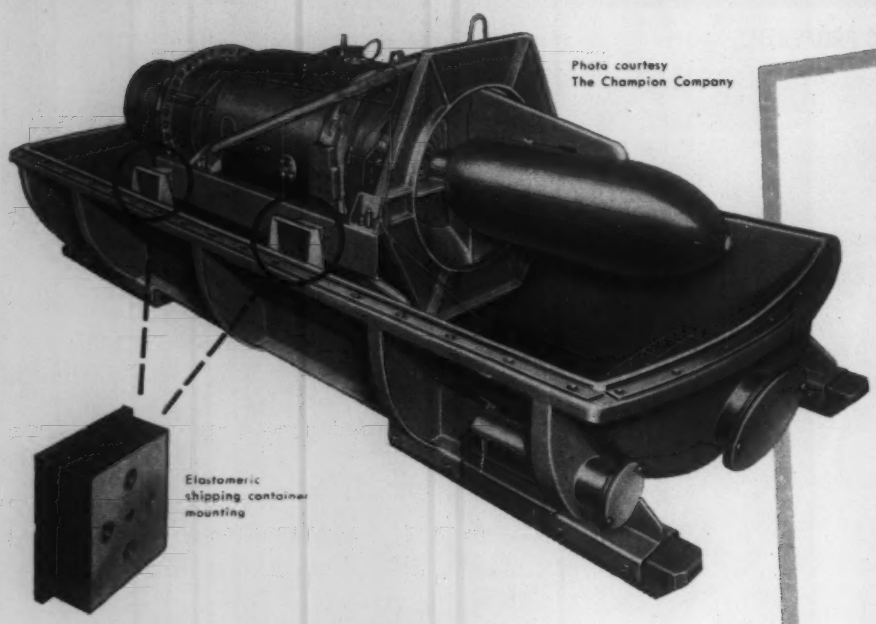
WSW 7327

ALLEGHENY LUDLUM

Export distribution: AIRCO INTERNATIONAL

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

MAINTAIN RELIABILITY



...with LORD shipping container mounting systems

You can safeguard the built-in reliability of sensitive or fragile equipment with LORD-engineered flexible suspension systems. Specially designed to eliminate damaging forces during shipment, these systems "float" the equipment on high-strength elastomeric mountings.

With this positive protection against damaging vibration and repeated shock, you maintain product reliability, avoid costly repairs or adjustments, eliminate wasteful ruggedness, assure good customer relations.

Many types of equipment are packaged on mounting systems designed and produced by LORD (see list). Both standard elastomers and LORD's new BTR (Broad Temperature Range) elastomer are available for systems which provide maximum protection plus vital cost savings. Compact design permits cost and weight reduction in the container. With complex units, an elastomeric system is the most economical answer.

For an engineered solution to your shipping damage problem, utilize the unmatched experience and facilities at LORD—*the pioneer and leader* in elastomeric shipping mounting systems. Contact your nearest LORD Field Engineer or the Home Office, Erie, Pennsylvania.

Lord Mounting Systems are protecting:

Aircraft
- Jet and reciprocating engines
- Control surfaces
- Airspeed-altitude computers
- Tail assemblies
- ATR electronic units
- Helicopter rotor hubs
- In-flight refueling kits
- Jato units

Missile
- Missiles
- Nose cones, warheads, other components
- Powerplants and boosters
- Solid propellant engines
- Rocket launchers
- Ground handling equipment

Electronic
- Tubes — magnetron, klystron, and others
- Computers
- Recorders
- Oscilloscopes
- Antennas
- Consoles and assemblies
- Television units

Miscellaneous
- Business machines
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- Telescopes
- Nuclear reactor cores
- Torpedoes
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... and many others

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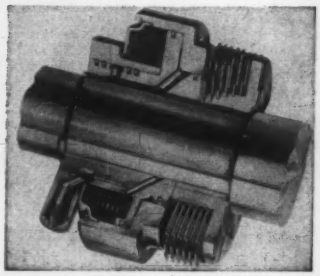


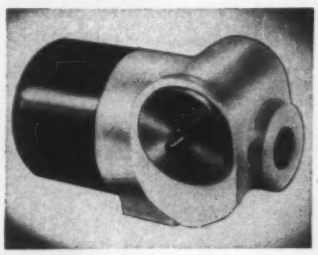
types are available in sizes from 3 to 7 in. in diam. They transmit up to 137 hp and up to 690 lb-ft of torque. With hydraulic balance, speeds up to 5000 rpm are allowable for smallest units and up to 3250 rpm for largest. **Twin Disc Clutch Co.**, Racine, Wis. K

Circle 695 on Page 19

Electric Motors

have 1/1000 to 1/3-hp capacity

Ecliptic fractional-horsepower electric motors are available in many models with 1/1000 to 1/3-hp capacity. Unit shown is ac or dc, reversible type, with maximum of 1/350 hp, continuous duty, 100 to 300 rpm. Sizes range up from 1¼ in. diam and 2½ in. long. Units



weigh from 7 oz up. Line includes universal, dc, ac, and pm types, induction, gear, governor, and brake types. **Carter Motor Co.**, 2719 A W. George St., Chicago, Ill. I

Circle 696 on Page 19

Snap-Action Switch

low-cost unit is for operation by cams

S30-97A snap-action switch provides long life and accuracy for linear cam, rotary, and rotary-pin actuation. Unit accepts clockwise and counterclockwise cam actuation with equal precision. Positive stop protects switch mechanism from damage due to excessive overtravel. Switch can be gang-mounted to pro-

Mac-it is on the move—to give you . . .

MORE REASONS TO SPECIFY MAC-IT SCREWS

Here's important news for users of alloy steel fasteners.

Mac-it is moving ahead on an aggressive program designed to provide better customer service through:

- NEW PRODUCTS
- PRODUCT IMPROVEMENTS
- ENLARGED FACILITIES
- BETTER DELIVERIES
- ADVANCED FASTENER ENGINEERING
- EXPANDED DISTRIBUTOR NETWORK

These significant developments are additional reasons for specifying Mac-it—**the screws that hold where others fail.**

Mac-it Parts Co., 275 East Liberty Street
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Mac-it

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MAC-IT SCREWS

HEX SOCKET, ALLOY STEEL CAP SCREWS • SET SCREWS • SPECIALS

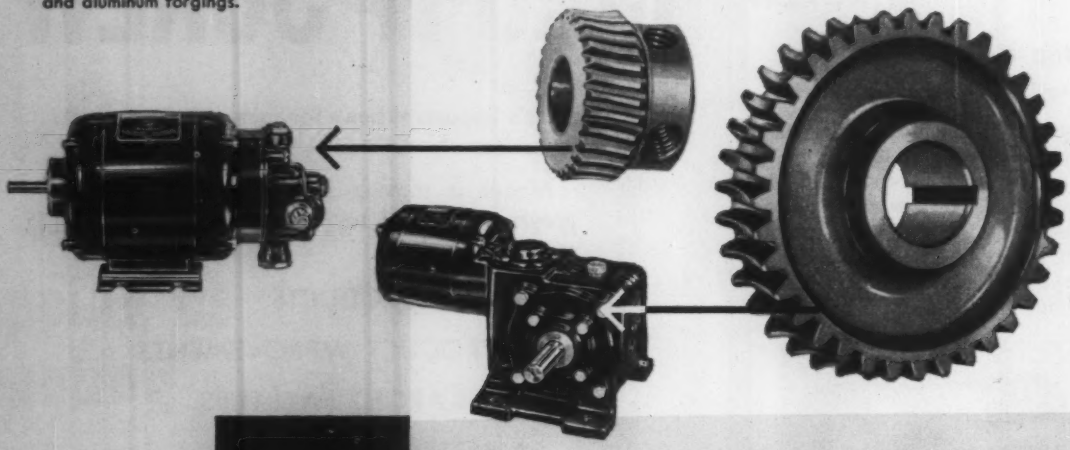
Circle 508 on Page 19

MUELLER BRASS CO. forged gears improve dependability and performance of BODINE electric motors

For combined high shear strength and maximum wear life in their single and double reduction speed reducer motors, Bodine Electric Company of Chicago uses gears forged from Mueller Brass Co. 603 Alloy.

Bodine has specified Mueller Brass Co. forged gear blanks because of their consistently high quality . . . there is no porosity, foreign inclusions or defects typical of cast blanks. The hot working of the metal followed by heat treatment to the desired physical properties produces a refined grain structure to give uniform machining and wear in service. The forged blanks are consistent in size and held to close tolerances. Bodine has also found that the excellent machinability of the blanks in the hobbing operation increases overall hob life.

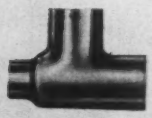
For forgings of high tensile strength, high density, minimum porosity, light weight, corrosion resistance, good machinability and low costs with little scrap loss, it pays to specify forgings from the Mueller Brass Co., the world's largest producer of brass, bronze and aluminum forgings.



only the man from Mueller Brass Co.

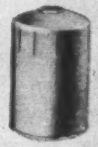
can offer unbiased advice on the "one best way" of producing your parts, because Mueller Brass Co. is the only fabricator in the country offering all these methods of production . . . assuring you the best product at the best price . . . made the one best way.

Write today for complete catalogs on any of these products.



FORMED COPPER TUBE

PLASTICS INJECTION MOLDING



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POWDER METAL PARTS

RED BRASS CASTINGS

Also producers of: Super Cutting Red Tip Brass Rod • Aluminum Extrusions Aluminum Sheet, Coil and Strip • Plastic Pipe and Fittings • Copper Tube and Solder Type Fittings •

MUELLER BRASS CO. PORT HURON 20, MICHIGAN

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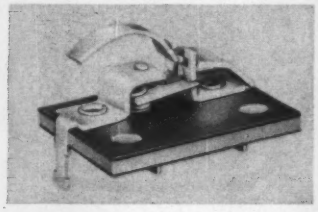


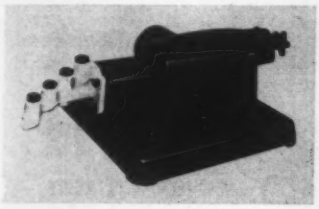
vide electrical control for multiple circuit variations. Operating force can be varied from 2 to 7 oz. Switch is rated at 10 amp, 125 v ac; 5 amp, 250 v ac; 1/3 hp, 125/250 v ac. **Cherry Electrical Products Corp.**, 1650 Deerfield Rd., Highland Park, Ill. I

Circle 697 on Page 19

Controlled-Volume Pump

incorporates totally enclosed speed reducer

New Milroyal controlled-volume pump uses a minimum of working parts and bearing surfaces to translate high-speed rotary motion to low-speed reciprocating motion. Totally enclosed speed reducer is an integral part of pump and runs in an oil bath. Polar-Crank drive unit and speed reducer permit manual or automatic adjustment of capacity from 0 to 100 per cent. Capacity adjustment closely approximates a linear relationship and can be made



while pump is running. Patented Step-Valve provides repeatable accuracies within ±1 per cent. Pump has maximum capacity to 29 gpm and meters against pressures to 1900 psi. **Milton Roy Co.**, 1300 E. Mermaid Lane, Philadelphia 18, Pa. E

Circle 698 on Page 19

Variable-Speed Sheaves

operate on fixed centers using 1-3/16 in. wide V-belts

New wide-belt, smooth-faced, variable-speed sheaves for fixed-center operation employ 1-3/16-in. wide V-belts. Combination of two sheaves and a hand control constitutes

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Circle 510 on Page 19

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for engineers!
STANPAT—the remarkable tri-acetate that is pre-printed with your standard and repetitive blueprint items, easily transferred to your tracings by an adhesive back or front. Relieves time-consuming and tedious detail of re-drawing and re-lettering specification and revision boxes, standard symbols, sub-assemblies, components and cross-sections. Saves hundreds of expensive hours of drafting time and money, frees the engineer for concentration on more creative work.
so simple to use:
① PEEL the tri-acetate adhesive from its backing.
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Name_____
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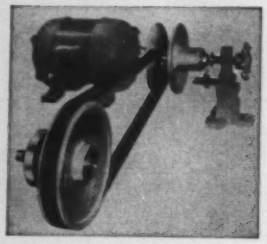
Address_____

Circle 511 on Page 19

a practical, low-cost, adjustable-speed drive. Controllable sheave is mounted on motor and spring-actuated sheave is mounted on shaft of machine to be driven. Drives are available in capacities of 1 to 3 hp with speed-change ratios



as high as 8:1. Employing a 1750-rpm motor, a speed range of about 400 to 3200 rpm can be obtained at driven shaft. Applications can be made on many machine tools. Speed Selector Inc., P. O. Box 312, Chagrin Falls, Ohio. F

Circle 699 on Page 19

AC Blower Motor

produces 0.2 oz-in. torque at 10,200 rpm

Model 65JG1 27-v, ac, three-phase, 400-cycle blower motor which meets MIL-M-13787 Signal Corps specifications has a diameter of only 1.07 in. and is 1.32 in. long. It produces 0.2 oz-in. torque at 10,200 rpm. De-

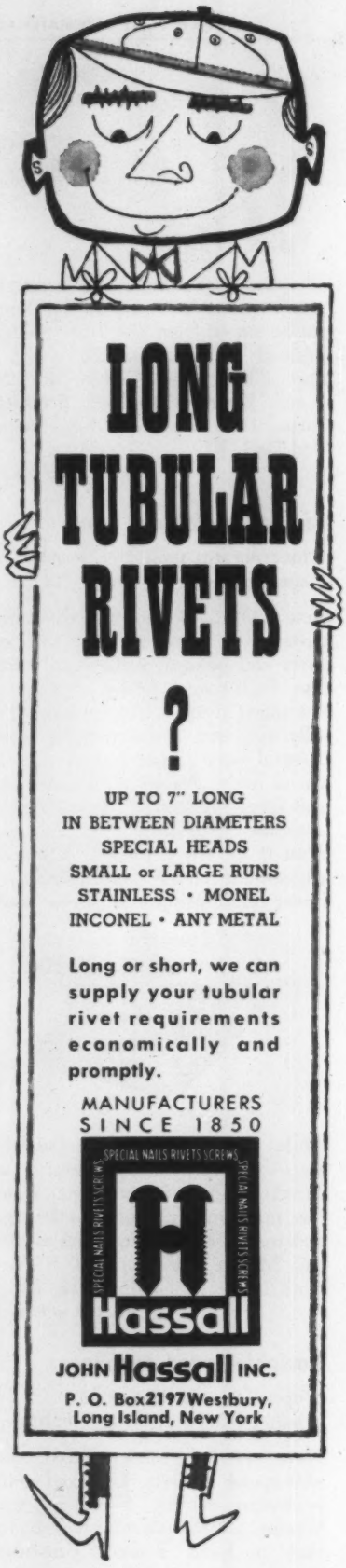
signed for continuous duty at 87 C with a life of 1000 hr, motor weighs only 3 oz. Western Gear Corp., P. O. Box 182, Lynwood, Calif. L

Circle 700 on Page 19

Quick-Disconnect Coupling

Withstands 22,000-psi burst test

Type 5-5002-8 quick-disconnect coupling for hydraulic and fuel lines in aircraft and missiles has withstood a 22,000-psi burst test. Coupling can be connected and disconnected manually under high pres-



Circle 512 on Page 19

One 75-ton OBI geared press (shown) and two straight side presses of 75 tons and 125 tons capacity respectively were converted with FSPA at Applied Arts. The complete FSPA package includes a Fawick CB Airflex Clutch and CS Brake mounted within a flywheel or bull gear, a Fawick Timing Rotorseal to function as rotary air seal and cycle timer, and Fawick High Speed Clutch Controls.

Fawick Clutch Controls make presses simpler to operate. Inching, single stroke or continuous operation are all controlled from a single panel. The cycle may be changed by turning a knob on the Timing Rotorseal —no chains or gears to adjust.

APPLIED ARTS CORPORATION, GRAND RAPIDS, MICH., IS A LEADING MANUFACTURER OF STAMPINGS AND FINISHED ASSEMBLIES. CHIEF ENGINEER J. H. WHITMAN POINTS OUT HOW . . .

"Fawick press conversions improve profits thru less maintenance and downtime"

"Modernization of three large presses to pneumatic action with FAWICK FSPA packages was a big step in improving their efficiency. We not only improved the over-all performance of the presses, but we actually saved money—and improved profits—in the long run. Here's why . . .

"First, our crew was able to install the new units right here at the plant. Each press was out of action for only a few hours.

"Next, in almost four years of operation, and through several million cycles apiece, these units have functioned very satisfactorily—with negligible downtime and minimum maintenance costs.

"We figure that the amount saved in maintenance and downtime, compared to the cost of operating presses with old-style clutches and brakes, has paid for the installation. And our operators are pleased with the way the presses respond to FAWICK's electro-pneumatic controls: the cycling is faster and more accurate—the safety is better."

Press and machine tool users all over the country are reporting similar results of modernization with FSPA. Call your nearest FAWICK representative to find out how you can benefit.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 Clinton Rd. • Cleveland 11, O.
Fawick Canada, Ltd., 60 Front St., West Toronto, Ontario, Canada

FAWICK Airflex

INDUSTRIAL CLUTCHES AND BRAKES

Circle 513 on Page 19

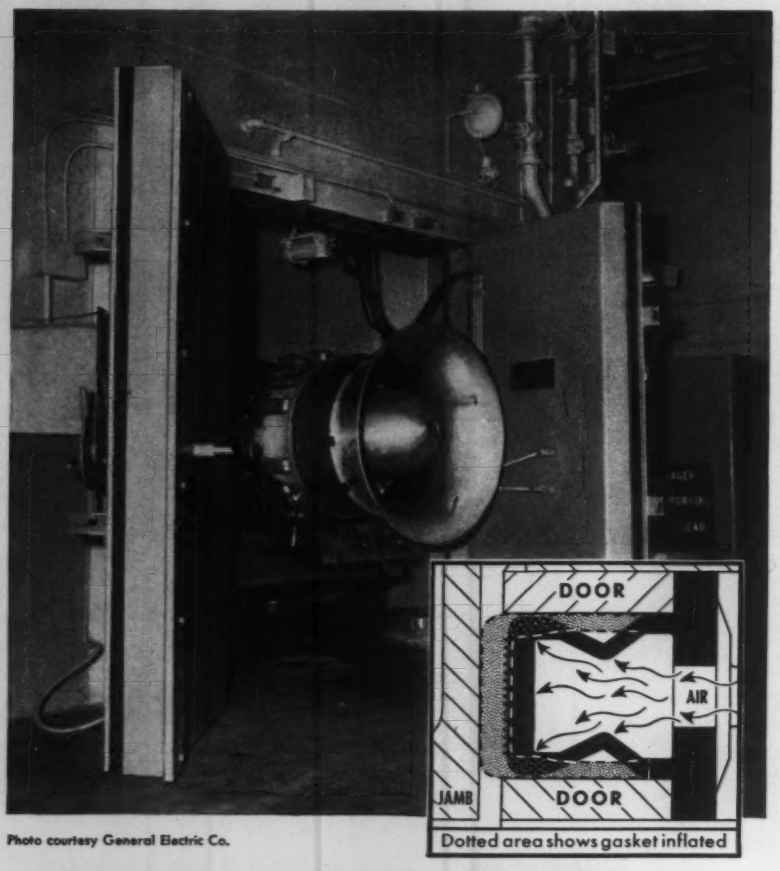


Photo courtesy General Electric Co.

Dotted area shows gasket inflated

Pneumatic Rubber *Door Seal* Muffles Test Cell Noises

To more effectively suppress noise, General Electric jet engine test cells are equipped with a unique pneumatic rubber door seal. Mounted on door perimeter, this seal is designed to expand proportionally and insure a perfect seal over its entire sealing surface *including the corners*. Not only does this gasket dampen the noise but it permits more accurate testing through quieter working conditions.

Continental engineers developed this pneumatic gasket for this and similar applications. Compounded of special flex-resistant rubber, this versatile gasket can be operated with intermittent flexing cycle *or* as a continuous seal—can be adapted to various other types of doors—for *either* pressure or vacuum rooms.

The design of this gasket typifies the engineering skill offered by Continental. When you need "engineered rubber parts"—molded or extruded—enlist the service of specialists—consult Continental.

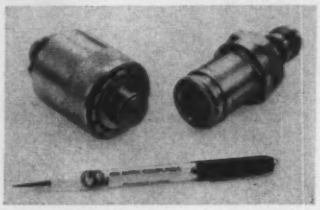
Engineering Catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**

engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA



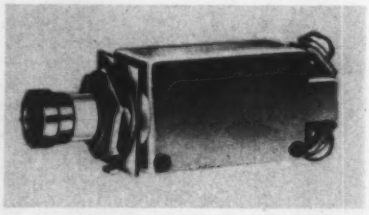
sure through elimination of steel balls and dogs. There is practically no loss of fluid when coupling is disconnected. Locking mechanism is smooth and positive, and will compensate itself as wear occurs, assuring excellent reliability and long life, since full 360-deg gripping action is used. **On Mark Couplings Inc.**, 4440 York Blvd., Los Angeles 41, Calif. L

Circle 701 on Page 19

Miniature Circuit Breaker

manual-reset unit has ½ to 5-amp ratings

Klixon 7274-1 miniature circuit breaker is designed for aircraft, radio, and electronic equipment in accordance with MIL-C-5809C (ASG). A manual-reset type, it has ½ to 5-amp ratings. Over-all dimensions are 1.420 in. high, 0.750 in. wide, and 0.560 in. deep. Configurations are available for installation in existing panels that accommodate NAF - 1357 panel-



mounted fuses and larger size neck-mounted miniature circuit breakers that use 15/32-in. threaded-mounting bushing. Maximum voltage drop is 1.25 v. **Spencer Thermostat Div., Metals & Controls Corp.**, Attleboro, Mass. B

Circle 702 on Page 19

Subminiature Relays

withstand 30 g vibration at 2000 cycles

New FC-2 subminiature, hermetically sealed relays are designed for power and low-level switching operations. They withstand 30 g vibra-

Circle 514 on Page 19

Many a "standard" was born a "special"

After almost a century of experience, solving thousands of fastener problems, Lamson offers many fasteners that started as "specials" but which grew up into "standards." Now they are available directly from stock and without the "special" higher price tag. If you have a "special" fastener problem check with us. We may have a ready-made "standard" answer for you.

The Lamson & Sessions Co.

L&S

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Cleveland 9, Ohio

Plants at Cleveland and Kent, Ohio
Chicago · Birmingham

Circle 515 on Page 19

LOOK WHAT HAPPENS

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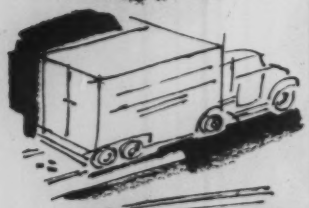

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Let us quote on your bulk or fabricated wire cloth needs. Samples for inspection or test purposes are available upon request. Call your Cambridge FIELD ENGINEER. He's listed in the phone book under "Wire Cloth." Or, write direct for FREE 94-PAGE CATALOG and stock list giving full range of wire cloth available. Describes fabrication facilities and gives useful metallurgical data.

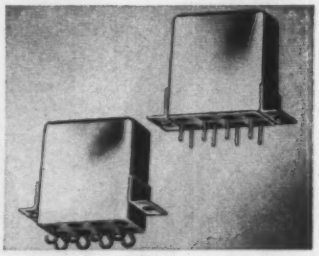
The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL-MESH CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

Department N,
Cambridge 11,
Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

tion at 2000 cycles, 50 g Class 2 shock, and −65 to 125 C ambient temperatures. Contact pressures, gaps, and follow-up meet shock, vibration, and load-handling (including low-level) requirements of MIL-R-25018 and MIL-R-5757C. Relays are available with hook ter-



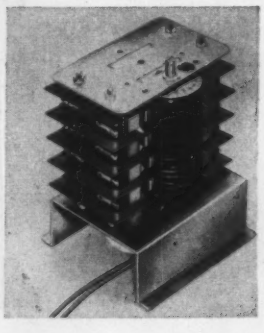
minals and short or long wire leads; terminals have 0.2-in. grid spacing. Contacts are rated 2 amp resistive at 26.5 v dc and 115 v ac, and are suitable for low-level operation. Struthers-Dunn Inc., Lambs Road, Pitman, N. J. E

Circle 703 on Page 19

Cycling Timers

for one to eight independent circuits

Type 511 and 521 cycling timers combine high accuracy with quick adjustability of up to eight independent timed intervals. Both throws of each SPDT load switch are controlled by separate cams, independently adjustable through 180 deg with small wrench. Cam setting is indicated on a dial in per cent of full cycle time, permitting accurate setting of make and break times for each switch. Type 511 provides from one to three load switches, Type 521 from four to eight. Cycle times available are from 6 sec to 48 hr. Switching accuracy is within 1½ deg for any one circuit, 3 deg between any two



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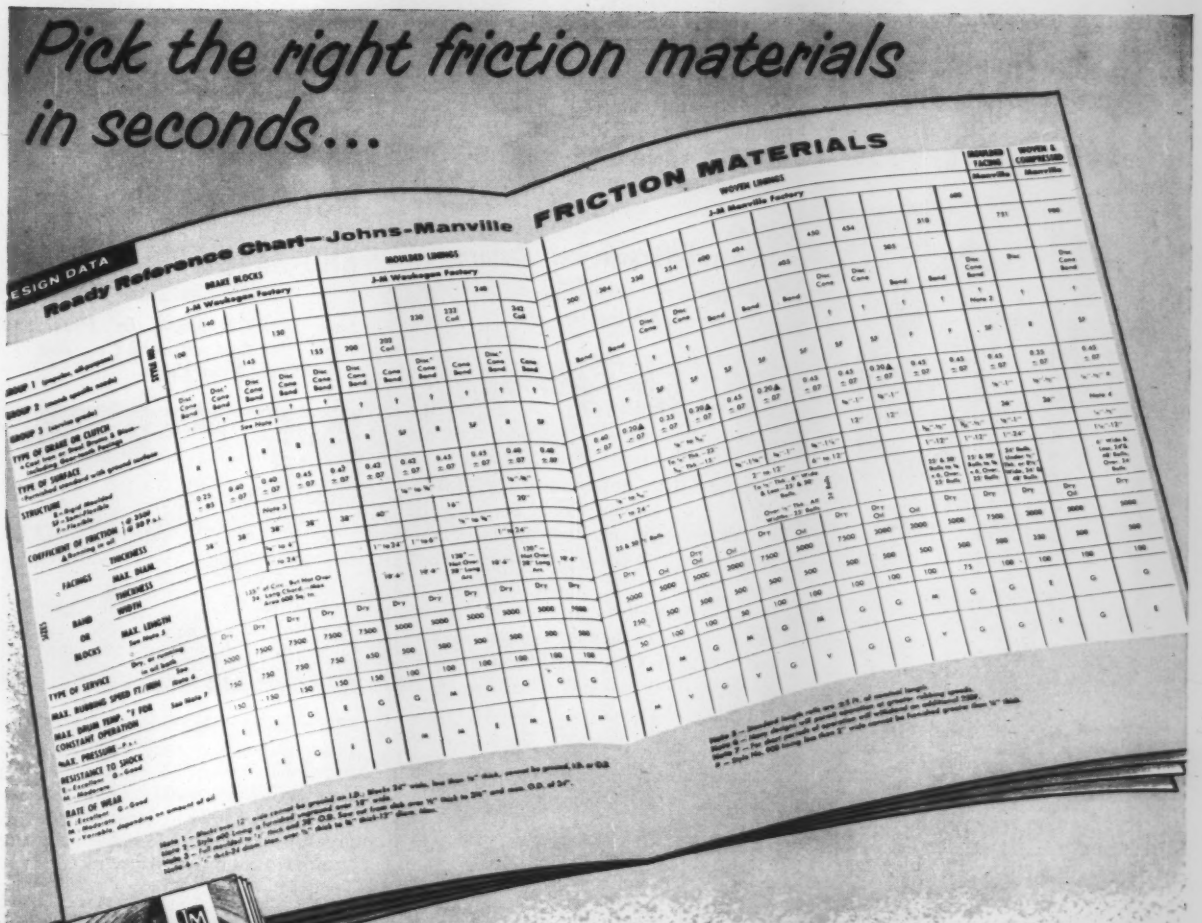

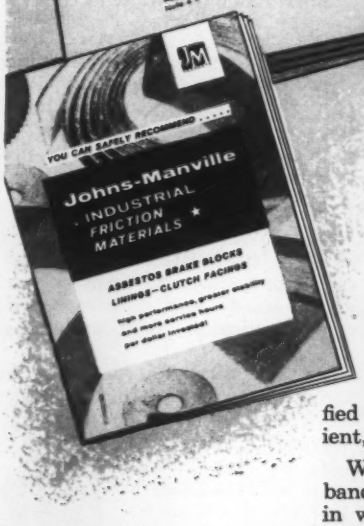
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WHEN YOU ENCOUNTER a design problem that involves the control of motion, you'll find this new, ready-reference book about Johns-Manville Friction Materials a big help. Its sixteen pages are loaded with specific design data, presented in simplified table form, that you'll find convenient, accurate and easy to use.

Whether you require a disc, cone, band, block or lining—for application in wet or dry service, heavy or light duty, slow or high speed operation, light or heavy pressure—this book will give you performance characteristics, available sizes and shapes, dimension data and tolerances.

Whatever your problem dealing with the control of motion the J-M Friction Material specialist . . . backed by unmatched J-M Research facilities . . . is at your service. Write Johns-Manville, Box 14, New York 16, N.Y., for your free copy of the Friction Materials Guide—FM35A. *In Canada, Port Credit, Ont.*

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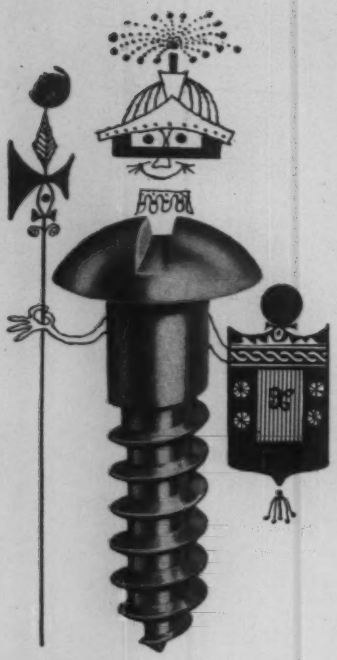
Johns-Manville *Industrial* FRICTION MATERIALS



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Don't let ugly corrosion stains spoil the appearance of your products. Make them of aluminum, fasten them with Alcoa® Aluminum Fasteners for lasting sales appeal. Low-cost, carefree aluminum fasteners protect your aluminum products against both galvanic and atmospheric corrosion. And they are readily available in complete stocks . . . all standard sizes and types at your local Alcoa distributor; or call your nearest Alcoa sales office. Look in the Yellow Pages of your telephone directory. ALCOA IS A "NATURAL" FOR SPECIALS, TOO!

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Circle 518 on Page 19

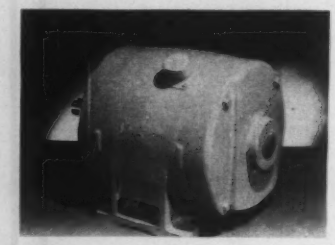
circuits. Load switches are rated for 20 amp at 125 or 250 v ac, motor for 115/230 v, 25, 50, or 60 cycles. Cramer Controls Corp., Centerbrook, Conn. B

Circle 704 on Page 19

Integral-Horsepower Motors

respond to both current and temperature

Inherently protected, three-phase, small integral-horsepower motors respond to both current and temperature for protection against excessive overload currents, stalls, single-phasing, and high ambient temperatures. Motors are for use where severe-duty cycles are encountered, and where a single control is used for more than one motor or where control is remotely located from motor. Inherent protection device, located on motor frame and protected by a pressed-steel cap, contains a snap-action thermal disc, three contacts, and three heating elements in a molded



phenolic base. Connections are made at neutral point of the motor. When thermal disc snaps open—either from high ambient temperature or excessive motor current—connection is broken at neutral point, interrupting current in all three motor winding circuits. After motor cools, protective device resets automatically and motor operation is resumed. General Electric Co., Schenectady 5, N. Y. C

Circle 705 on Page 19

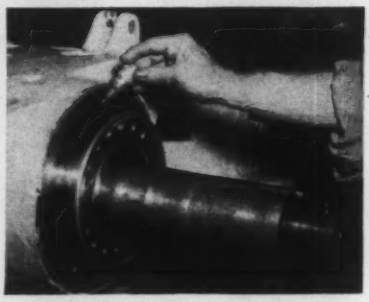
Seamless Tubing

of beryllium copper in 0.10 to 0.625-in. OD sizes

Seamless tubing of No. 25 beryllium-copper alloy is available in sizes from 0.10 to 0.625 in. OD and wall thicknesses from 0.042 to 0.001 in. Alloy is for appliance, electrical, and electronic component use. It has excellent spring characteristics, high tensile strength, high electrical con-

"WE REPLACE 9" BEARINGS IN LESS THAN AN HOUR... INSTEAD OF 3 TO 4 DAYS—AND SAVE $155.00 EACH"

Says David B. Cook, Jr., President Acme Road Machinery Co., Inc. Frankfort, New York



"Replacing 9-inch bearings in the jaws of a giant rock crusher once required days to bore the housing and build up weld metal for reboring to a .0015" interference fit. Even then, placing the bearing took two men 3 or 4 hours.

Now, thanks to LOCTITE Liquid Sealant, we prepare the housing, clean and insert the bearing with a slip fit in less than one hour! Crusher jaw bearings locked in with LOCTITE have been in rugged service for many months without report of a single failure."

You, too, can eliminate interference fits. LOCTITE hardens between bearing and housing to form a bond that exceeds any interference fit . . . requires no heat or mixing.

Write for further information on money-saving LOCTITE applications in production or service . . . for slip fitting bearings, bushings, hardened sleeves and rotors on shafts; for locking threaded fasteners or studs securely; for sealing against high-pressure fluids.

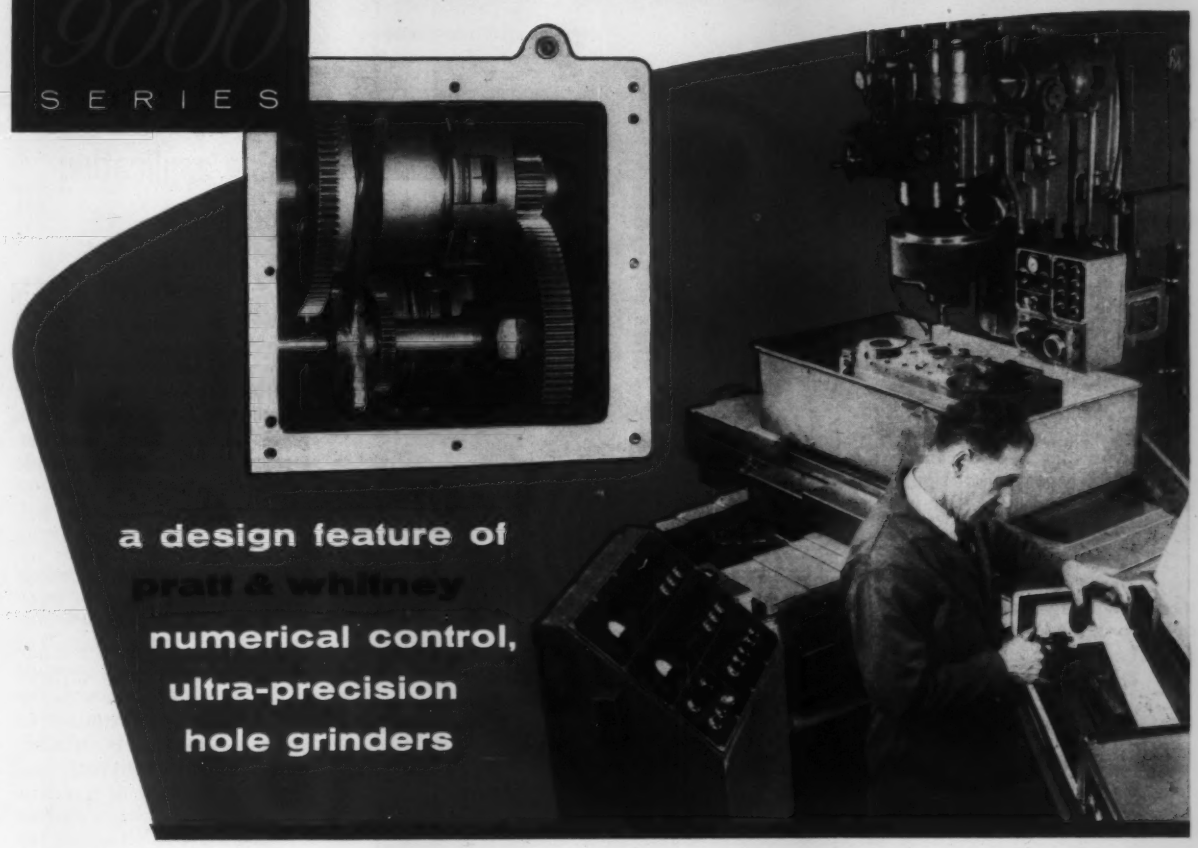
LOCTITE® SEALANT
AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.
In Canada: J. S. Parkes & Co., Ltd., Montreal

Circle 519 on Page 19

new Maxitorq

electric clutches and brakes

9000 SERIES



Again a famous machine tool builder favors today's outstanding electric clutches and brakes

Previously, Pratt & Whitney incorporated MAXITORQ Clutches in their high-precision jig borers. Proved performance led their engineers to test and accept the new 9000 series MAXITORQ Electric Clutches for their latest development . . . the fully automatic, numerically controlled, ultra-precision Vertical Hole Grinder and Electrolimit Jig Borers. Inset photograph above shows the compact and "clean" installation of two of these clutches in the carriage control drive gear box.

Incorporating new and advanced design principles, the 9000 Series MAXITORQ Electric Clutch is well adapted to machine tool drives. It is simple in design . . . built to machine tool standards . . . requires no adjustments. It can be used *either as a clutch or brake*. Disc separators not only separate discs but also break up residual magnetism, and result in extremely fast, positive action with no drag or heating in neutral. Design principles have been PROVED through years of service. There are few moving parts. Electrical operating unit remains stationary—hence, there are no troublesome slip rings or brushes; no difficult wiring problems. Clutches operate on standard 110 V a.c. converted to 90 V d.c. Other voltages on special order.

If you have a clutch or brake application where you are looking for NEW and IMPROVED performance, we invite you to bring the problem to us.

Phone, wire or write Dept. MD-11 for new #9000 Series bulletin

6CJ58

The Carlyle Johnson Machine Company, Manchester, Conn.

TIMERS...SPECIAL DELIVERY

Standard or special— Industrial Timer makes rapid deliveries on all models

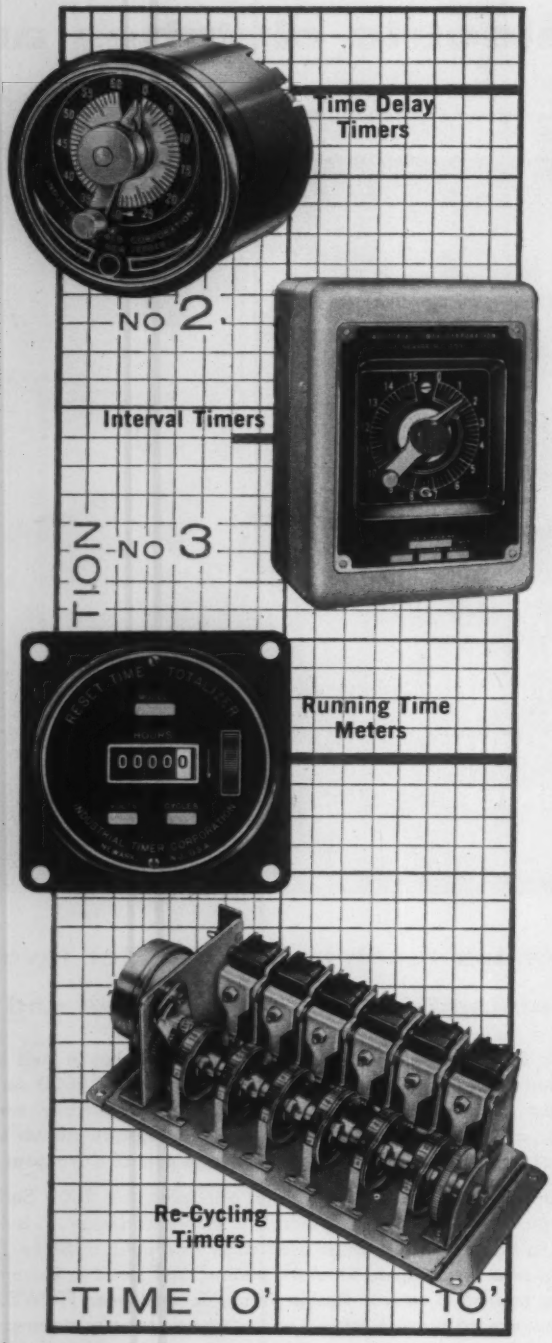
Sometimes you need a standard model timer . . . other times you need a special. Either way we can give you the extra rapid service you may need because of the efficient way we design, manufacture and stock timers for industrial applications.

To meet *all* of the widely varying needs of our customers we manufacture a complete line of timers in the four broad classifications illustrated here:

1. TIME DELAY TIMERS
2. INTERVAL TIMERS
3. RE-CYCLING TIMERS
4. RUNNING TIME METERS

From these we have already developed 20 basic types which can be combined in endless number of ways . . . to date, our engineers have combined them into over 1000 different models. So what might seem to be a special timer requirement to you, will very often be a standard timer in our large stock, and that is the reason we have the ability to fill special orders so quickly. And as far as standard timers are concerned we can give overnight service if necessary.

So, for the utmost in all-round service depend on us for this outstanding combination: deliveries "Immediate on Standards . . . First on Specials".



Speed up your automatic control projects— profit by our timing application experience

No need to let timing problems delay you in your automatic control projects when you can place them with us and get faster solutions. Even though no two automatic control jobs are ever exactly alike, and even though the timer requirements of each are very different we have established an excellent record in helping out in these situations.

20 years of experience in analyzing complex timer applications has provided us with the special knowledge required to give our customers the right answer in near-record time.

Our large stock of standard and combination timers enables us very often to fill orders for these requirements without any time loss because we have already developed so many new combinations specifically for automatic control functions.

Extra special automatic control timer — this calls for original designing. Our engineers will go right to work and get the job done. That's the way we grow and we like it.

Whatever your control problem, you have everything to gain by submitting it to our timer specialists. They'll come up with the answer — almost with the speed of automatic control itself.

AFFILIATE—LINE ELECTRIC COMPANY

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

1413 McCARTER HIGHWAY, NEWARK 4, N. J.

Circle 521 on Page 19

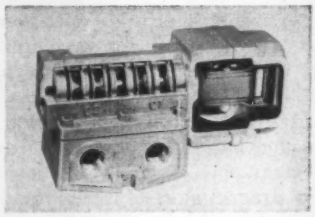
ductivity, and good forming properties. Uniform Tubes Inc., Collegeville, Pa. E

Circle 706 on Page 19

Air-Control Valves

four-way units are in 1/4 to 3/4-in. pipe sizes

New four-way air-control valves are available in single and double solenoid-operated models and single or double pilot (air)-operated master valves. Pipe sizes are 1/4, 3/8, 1/2, and 3/4 in. Controlled expansion seal provides positive sealing in all operating ranges from 28 in. vacuum to 150 psig, and has low breakout friction. Balanced, direct-operated spool allows use of small, low-amperage solenoids for direct operating force. Short spool stroke and direct operation make possible complete reversal of valve position in less than one electrical cycle. All



valve seats are replaceable and provide floating alignment of all parts. Air Valves Co., 22729 Hoover Rd., Warren, Mich. H

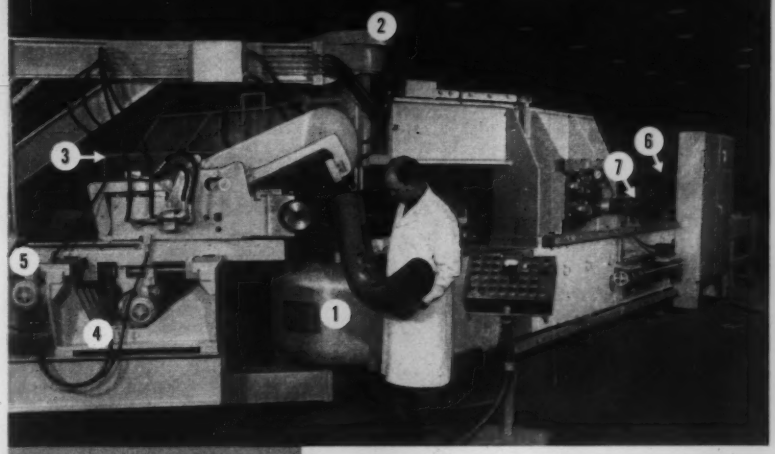
Circle 707 on Page 19

Protective Relays

control distribution of electricity

Two new protective relays are used to control distribution of electricity. Type CDG, shown, is an induction-disc relay with inverse time characteristics and adjustments for time and current pick-up. Used for selective phase and ground fault protection of feeders on distribution systems which require isolation of

You can solve many problems better and at lower cost with DIAMOND Roller Chain



In all 7 strategic power transmission locations... world's largest aircraft TUBE BENDER uses

DIAMOND ROLLER CHAIN

1. Main drive chain for bending die boss
2. Swinging arm return chain
3. Power adjustment of pressure die holder
4. Drive chain to position clamp die holder lengthwise on swinging arm
5. Power drive for transverse positioning of clamp die holder along swinging arm
6. Power drive for positioning bending mandrel extractor lengthwise on machine
7. Power drive for mandrel return limit switch (for varying mandrel stroke)

This giant Pines tube bender is capable of bending ultra-thin 8" O.D. x .020" wall stainless steel tubing for jet aircraft air and fuel ducts.

Because dependable, accurately controlled power transmission is essential to each phase of the tube bending cycle, Pines engineers specified DIAMOND Roller Chain for all 7 power drives.

DIAMOND engineers will be glad to help you work out roller chain drives that will result in better design, better performance and lower operating costs for your product.

DIAMOND *publishes a complete library of roller chain information for design engineers . . . available to you upon request, without obligation. Write today.*

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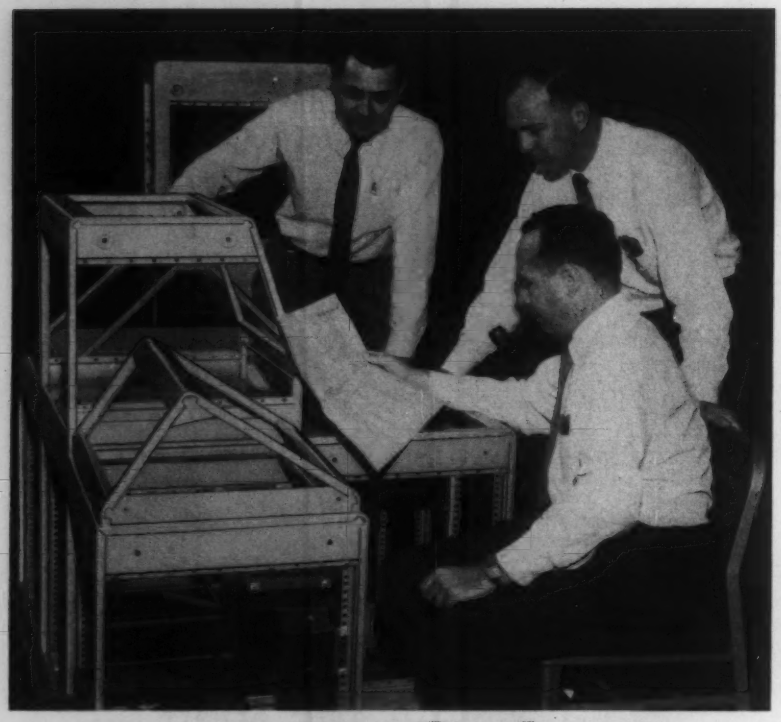
DIAMOND ROLLER CHAINS

Circle 522 on Page 19



NEW **EMCOR**®*

PACKAGING CONCEPT FOR AIRLINE COMMUNICATION

Your copies of "The Story of the EMCOR Modular Enclosure System For Industry" and Catalog 105 are available upon request.

Shown above are representatives of Eastern Air Lines, Inc. in a planning session to determine modular enclosure requirements for communication control equipment. Left to right: L. J. Fay, EMCOR's Chief Engineer; J. W. Bussey, upper right, of Eastern Air Lines; and D. R. Buckler, Manager of Eastern Air Lines Communications Facilities. They are evaluating the use of a variety of frames planned for Eastern Air Lines new installation, Idlewild Airport, New York. Of primary interest are the versatility, flexibility and durability of EMCOR's new electronic component packaging concept in metal cabinetry ... THE EMCOR MODULAR ENCLOSURE SYSTEM. Design know-how for packaging components in standard frames makes possible the arrangement of groups of intricately wired instruments, indicators, dials and electronic scopes to increase visual and manual operation while minimizing environmental fatigue and strain.

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QUALITY EMCOR PRODUCTS

Originators of the Modular Enclosure System

ELGIN METALFORMERS CORP.

630 CONGDON, DEPT. 1226 • ELGIN, ILLINOIS

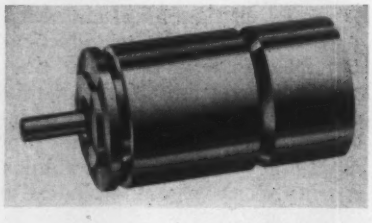
faulty sections on time graded principle, it also has application in the protection of ac machines, transformers, and other units either directly or as back-up to differential relays. Standard ranges of 0.5 to 2, 1.5 to 6, and 4 to 12 amp are available in this type; each range is adjustable in seven steps. Var 11, designed for reclosing electrically operated breakers, provides antipumping, self reset, and lockout if fault persists. Standard voltage ratings are 48, 125, and 250 v dc, and 115 and 230 v ac. **Federal Pacific Electric Co.**, 50 Paris St., Newark, N. J. C

Circle 708 on Page 19

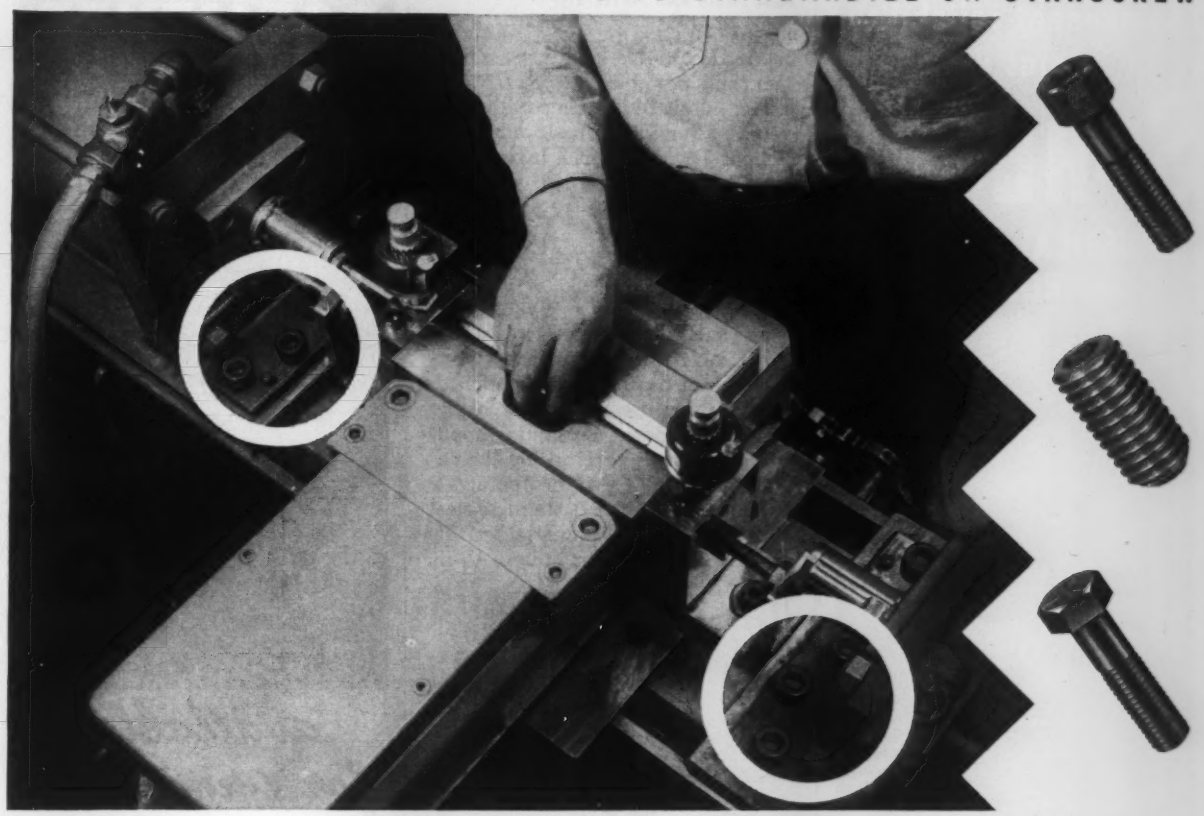
Miniature Servo Motor

provides damping without loss in steady-state velocity

New size 8 inertia-damped servo motor is designed for acceleration and deceleration damping in subminiature systems without loss in steady-state velocity. Damping is provided by viscous friction induced by magnetic coupling of a low-inertia drag cup to a freely rotating magnet flywheel, permitting same upper-corner frequency improvement offered by ac notching filters or dc lead-lag networks. Applications include positioning servos in which some overshoot can be tolerated to achieve fast settling time, or servos which allow no loss in velocity constant. Low-inertia rotor, combined with stall torque of 0.25 oz-in., produces acceleration at stall of 73,-



IT PAYS TO STANDARDIZE ON **STANSCREW**



A 20-ton impact load . . . 14,400 times a day! Stanscrew Fasteners solve the problem

Fastening the air cylinders on this tube former is a real problem. Each of these 8″ bore cylinders delivers a thrust of over 20 tons every time the machine is operated. And since this happens 14,400 times in a normal working day, ordinary fasteners would soon fail under these repeated shock loads. Furthermore, not even the slightest misalignment can be tolerated in this machine.

The Stanscrew fastener specialist was able to quickly answer this demanding problem. His solution was Stanscrew Socket Head Cap Screws, tightened to within 80% of yield strength so they remained in tension. These fasteners, so applied, deliver a clamping force that eliminates the shock feature of this extremely high loading . . . and provides a 100% factor of safety.

Tough assignments like this are everyday jobs for your Stanscrew fastener specialist. Immediately on call, through your Stanscrew distributor, he can bring to your problem years of specialized experience. And, back of him, is an outstanding staff of engineers who have been solving the fastener problems of American industry since 1872.

Stanscrew's complete line of more than 4,000 different types and sizes will provide economical answers to your fastener requirements. All 4,000 items are always in stock, quickly available.

Call your Stanscrew distributor today for solutions to your fastener problems. He will arrange a prompt meeting with the Stanscrew fastener specialist . . . who can often suggest ways to save you money by substituting standard fasteners for costly specials.

STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Circle 524 on Page 19

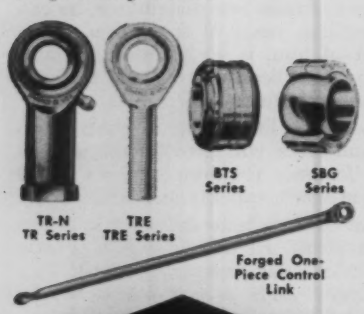
Component reliability begins with

SPHERCO®

SPHERICAL BEARINGS and ROD ENDS

Cutaway View of TRE Male Rod End

- Precision-built for superior performance.
- Solid race construction
- Wide range of designs, bore sizes, materials, etc.
- Prompt delivery schedules
- Engineering service



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SPHERCO

A PRODUCT OF SEALMASTER BEARING DIVISION STEPHENS-ADAMSON MFG. CO.

18 RIDGEWAY AVE. • AURORA, ILL.

Circle 525 on Page 19

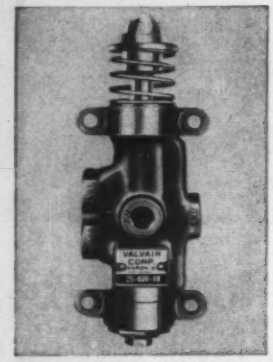
500 rad/sec². No-load speed is 6000 rpm, and power input is 2.6 w per phase. Unit resists temperature extremes, humidity, and vibration. Helipot Div., Beckman Instruments Inc., Fullerton, Calif. L

Circle 709 on Page 19

Manual Valve

is ball-cam actuated

New ball-cam-actuated manual valve, designed for operation by any mechanism having linear motion, is intended for use on press controls, with air cylinders, or similar applications where straight-line actuation is desired. Valve incorporates a ¾-in. diam hardened stainless-steel ball, locked in a stainless-steel retainer. Ball rests on three ¼-in.



diam stainless-steel carrier balls in a lubricant-packed cavity. Ball-cam end section can be used with any combination of two, three, or four-way Valvair valve bodies and end sections. Three and four-way types are available with open-end or piped exhaust, and all valves are suitable for hydraulic and pneumatic or vacuum service. Port sizes range from ¼ through ¾ in. NPT. Valvair Corp., 454 Morgan Ave., Akron 11, Ohio. F

Circle 710 on Page 19

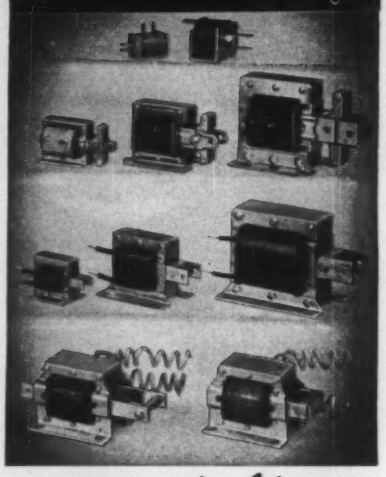
Fixed-Bore Sprockets

have standard keyway and setscrew

New line of fixed-bore roller-chain sprockets are furnished complete with standard keyway and setscrew, and are marked for easy identification of size and type. Each sprocket is ready for installation with no reworking required. Bores are accurately finished and are concen-

DORMEYER

CUSTOM QUALITY STOCK SOLENOIDS



available for immediate delivery

The line consists of 17 models to provide 34 widely differing specifications . . . delivery can be made within 24 hours of receipt of order . . . specifications include: pull and/or push capacities up to 45 lbs., . . . sizes from ¾"x 1⅛" to 3"x 3"... stroke lengths fractional to 2".

All solenoids are built to rigid standards of highest custom quality. Double shading coils provide high sealed pull without excessive AC hum. Electrical characteristics are thoroughly uniform. Units are compactly engineered to extremely close tolerances. Rugged construction provides long service-life under the most strenuous conditions.

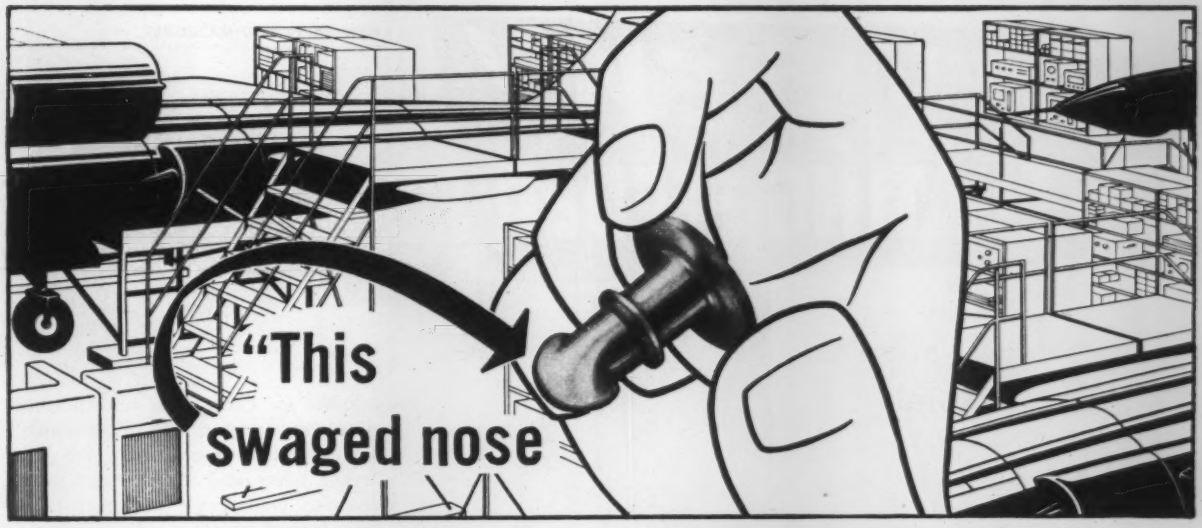
All solenoids in the line can be supplied in any quantity from single units to long-run cost-saving production orders.

Request complete information. Ask for catalog.

DORMEYER INDUSTRIES

3434 N. Milwaukee Avenue, Chicago 41, Illinois

Circle 526 on Page 19



on LION *Quarter-turn* FASTENERS is the secret of reliability, a high strength-weight ratio and smooth, positive operation."

Private, commercial and military aircraft and missile manufacturers' experience with LION QUARTER-TURN FASTENERS for airborne applications and ground operations have justified their choice of these inexpensive, dependable fasteners. They provide quick access through hinged or removable panels. Locking and unlocking is accomplished quickly and smoothly.

Approved for aircraft use—Designed to meet Military Specifications, Lion Quarter-turn Fasteners conform to Mil. Spec. MIL-F-5591A (ASG) . . . are on the Government's QPL . . . are CAA approved for commercial and private aircraft use.

Lion Fasteners consist of three parts . . . a one-piece, swaged-nose stud having no cross pins to install or to become misaligned; a retainer; a floating receptacle which is riveted or welded in place. Installation requires no special tools . . . is simplified by a permissible float of .070".

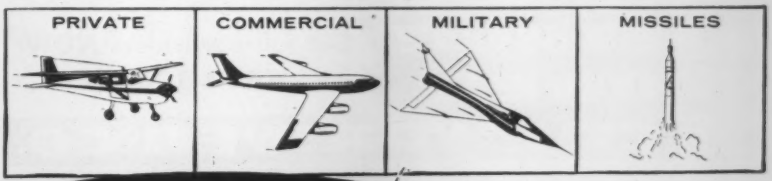
Two types in various sizes available. Model No. 2 is used where space is limited and light weight is essential, Model No. 5 meets severe conditions of shear, tension and vibration.

Full range of heads offers flush, oval, wing, ring, knurled, and notched head and key.

FREE!

Send for your free copy of Southco Fastener Handbook No. 8. Gives complete engineering data on Lion Fasteners and many other special fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

LION *Aviation* **FASTENERS**



one of the SOUTHCO FASTENERS LION

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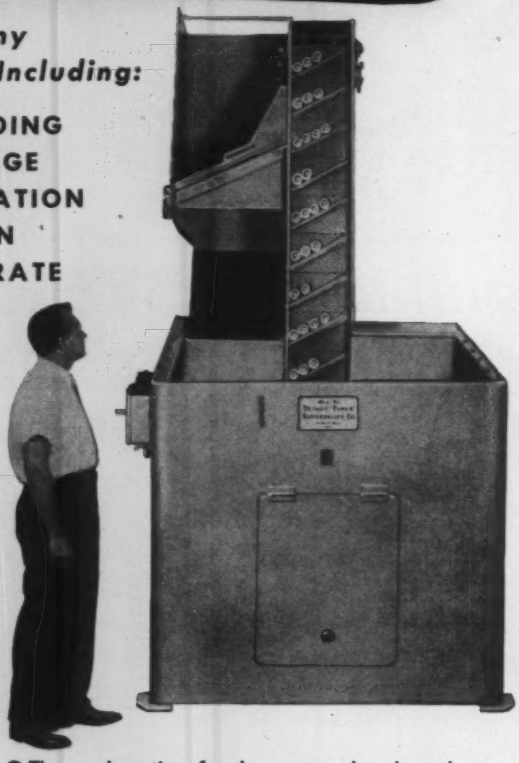
- ORIENTATION
- HIGH FEED RATE
- MINIMIZED RELOADING



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3 SIZES
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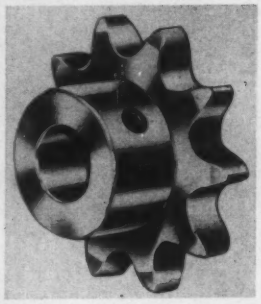


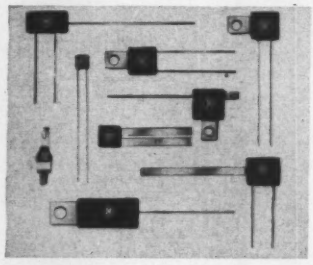
tric to sprocket pitch and bottom diameters within ASA standards. Line includes more than 425 different bores and 99 different tooth sizes to meet practically any power - transmission need. **Cullman Wheel Co.**, 1344 Altgeld St., Chicago 14, Ill. J

Circle 711 on Page 19

Ceramic Capacitors

subminiature units have new lead arrangements

Subminiature ceramic capacitors are available in a wide variety of lead arrangements in any of 12 ceramic materials. Greater choice of sizes, temperature ranges, and characteristics is provided, in addition to unlimited selection of wire, ribbon, or tab terminals in any number, thickness, or configuration. Ceramic elements also vary from square to rectangular, with thicknesses as low



as 0.065. Two or more elements can be stacked in parallel for higher capacitance. **Mucon Corp.**, Dept. K, 9 St. Francis St., Newark 5, N. J. D

Circle 712 on Page 19

Teflon Hose Assemblies

extremely flexible units are for high-temperature use

New Springfield 400 Teflon hose assemblies are available for high-temperature and corrosion-resistant

OSTUCO WELDED TUBING

solves your fabrication puzzles

Product design dilemmas . . . or production problems? Solutions to these perplexing puzzles fall right into place *naturally—with Ostuco Welded Tubing.*

First, Ostuco Welded Tubing is one of the most versatile of all materials. It can be subjected to virtually every fabricating operation known.

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Third, when you deal with Ohio Seamless you're dealing with tubing *experts* . . . men who can recommend the *exact* Ostuco Welded Tubing to suit your product and processes. Just contact our nearest sales office, or the plant at *Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.*

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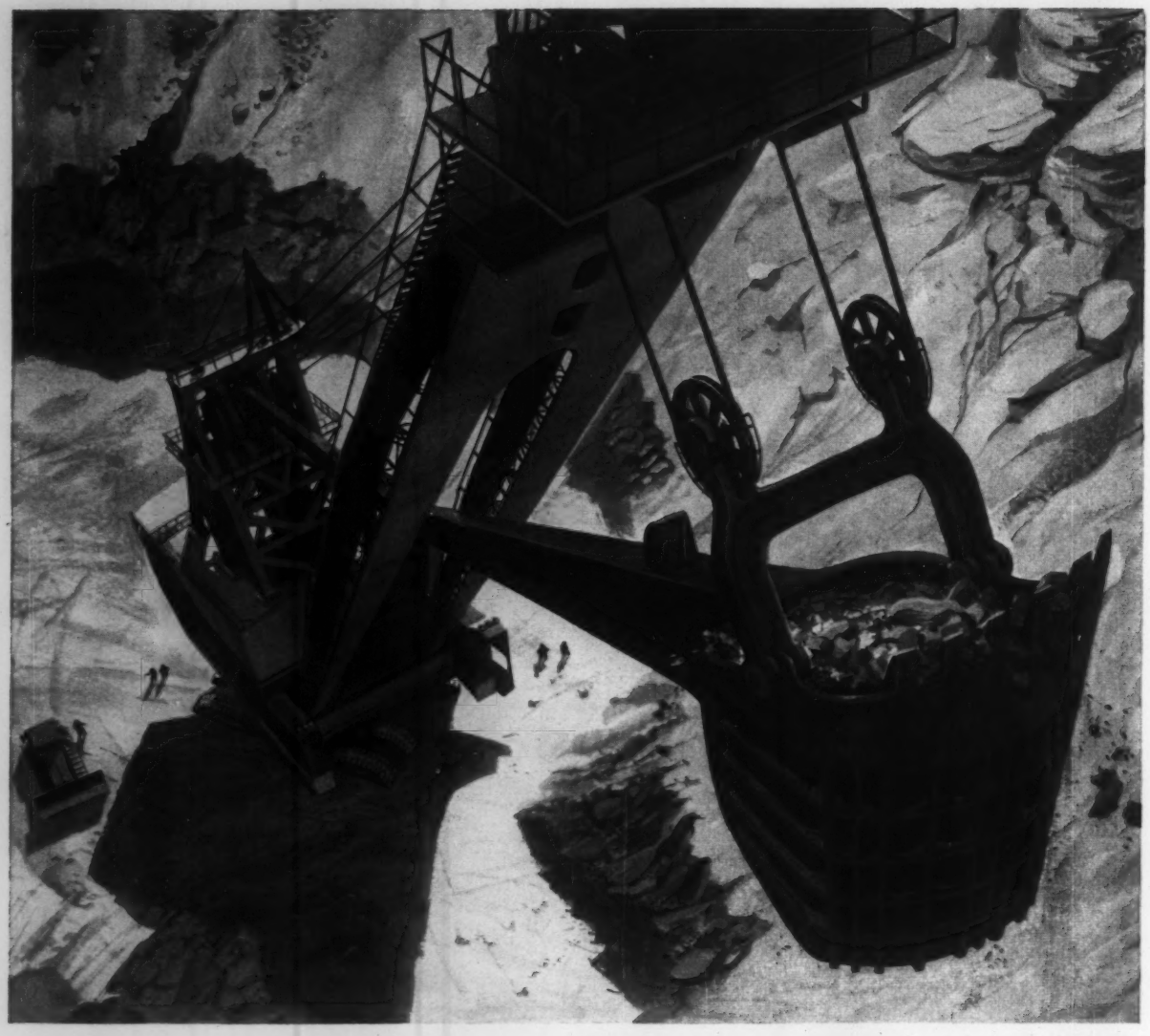
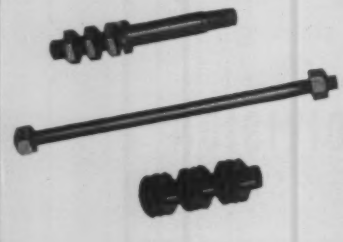
Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Moline, New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Richmond, Rochester, St. Louis, St. Paul, St. Petersburg, Salt Lake City, Seattle, Tulsa, Wichita. CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York.

Circle 529 on Page 19



World's Biggest Eater Dines Without Interruption



Typical insulator and insulating bolts used on power shovels.

You are looking at 3 million dollars' worth of power shovel, a 14-story monster capable of biting off 70 cubic yards of dirt at a clip.

Continuous operation is essential because downtime on a shovel of this size could top 500 dollars an hour. Reliability is shared by many interrelated parts. Some are made of Synthane laminated plastics.

Why Synthane? Because Synthane laminated plastics have the right combination of properties—dielectric strength, mechanical strength, and ease of machining. And Synthane uses only first-quality raw materials, watches every step in the production and fabrication of the laminate, is deeply concerned about delivery requirements.

Good materials, competent people, excellent tools and workmanship may not guarantee reliability but they're strong assurance of it.

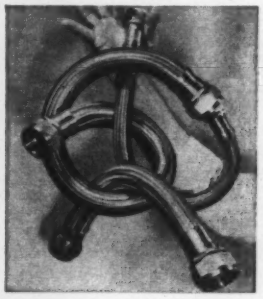
If you are interested in a reliable source of laminated plastics—sheets, rods, tubes, or completely fabricated parts, write for an interesting catalog or call our representative near you.

SYNTHANE

SYNTHANE CORPORATION, 5 RIVER RD., OAKS, PA.

Circle 530 on Page 10

industrial applications. Hose has excellent flow characteristics because of low convolutions found in inner tube. Assemblies are furnished in diameters from ¾ to 2 in., and have minimum bend radius of three and one-third times equivalent tube size. Hose flattens out when assemblies are bent below minimum bend



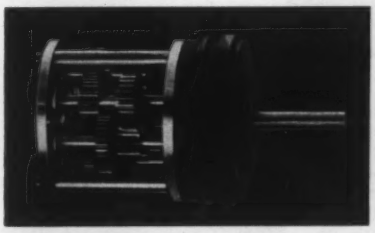
radius, but returns to original shape with no evidence of permanent damage to inner tube or braid. Temperature range is from − 65 to 400 F. Titeflex Inc., Hendee Street, Springfield 4, Mass. B

Circle 713 on Page 19

Speed Reducers

in sizes 8 to 18

New gear heads and speed reducers are available in sizes 8 to 18. All units have high torque-transmittal capacity to size ratio, and maximum backlash of 30 min. They operate in temperatures from − 55 to 150 C, and conform to all applicable mil-



itary specifications. Wide variety of ratios is available. Synchro-solve Inc., 269 Green St., Brooklyn 22, N. Y. D

Circle 714 on Page 19

Elapsed-Time Indicators

low-cost units have phenolic plastic cases

Series 53 low-cost, Bakelite-case, elapsed-time indicators are unsealed and available in 3½-in. round and 3½-in. square models. They are

"... JUH HEAR THE ONE ABOUT THE SIGMA RELAY FOR A BUCK?"
"LAND SAKES —A CHEAP SIGMA RELAY!"
ELECTRONICS CONFIDENTIAL
"HONEST CHARLIE— I'M TELLIN YA SIGMA MAKES PLAIN LITTLE RELAYS"
"I SAY, WITHERSPOON, HERE'S AN ODD SPOT: A SIGMA RELAY FOR SIX BOB"
"HEY AMBROSE - LETS FLY OVER AND SEE THE NON-MILITARY SIGMA RELAY"
"ANY TRUTH TO THAT RUMOR ABOUT A SIGMA RELAY FOR US POOR FISH?"

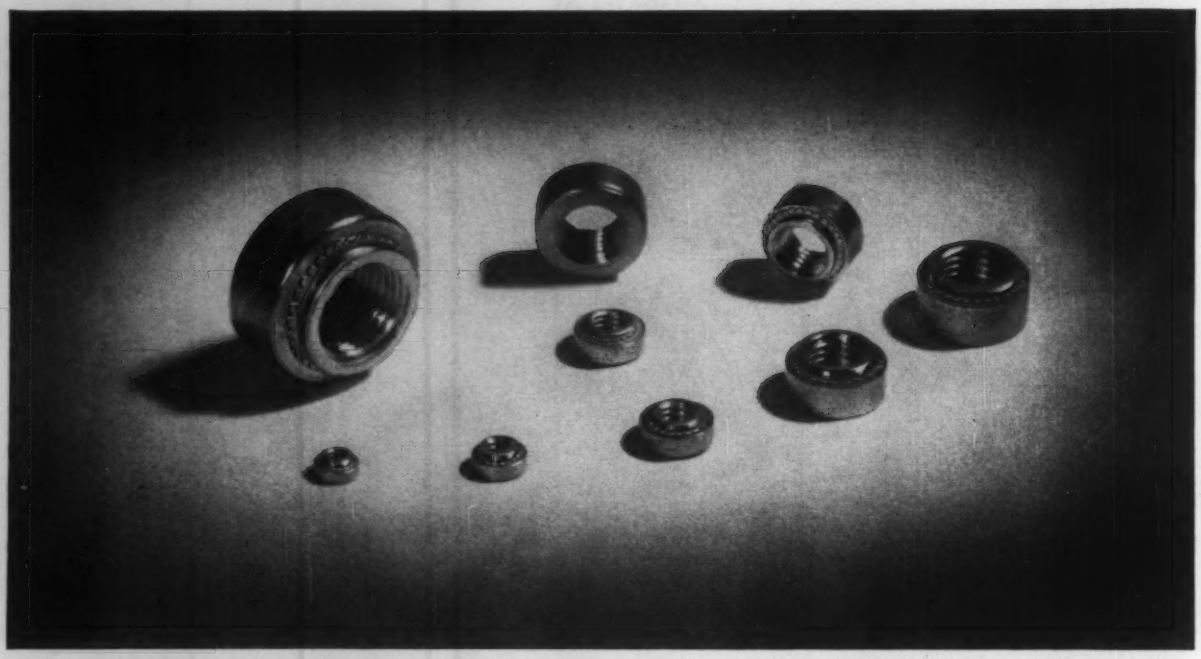
Our only regret about these conversations is the element of amazement, disbelief or surprise present in all of them. Apparently, we've been so busy all these years convincing people we could build complicated, high priced, MIL spec relays in small quantities that nobody* even gives us a competitive come-hither when they want a good, plain, cheap relay deliverable by the carload. Well, there are Sigma relays for short-haired jobs, and the 11F is an example. The "eleven" has been completely tooled for more than two years now, so it's no worry to the Eng. Dept. Delivery schedules in excess of 5000 per week are being met. The Sales boys like it because it sells for under a dollar (big quantities, of course). For on-off SPDT switching of 1 or 5 ampere loads on 50 mw. or 200 mw. DC, 0.3 volt-ampere AC, with a mechanical life of 100 million operations, it's hard to find anything as compact, cheap and dependable as the 11F. For things like tape recorders, remote control units for toys and TV sets, headlight dimmers, or other gadgets requiring UL approval, the "eleven" is a natural. Sample quantity prices are $1.50 to $2.45 each, list. Bulletin on request.

*well, hardly anybody.

SIGMA

SIGMA INSTRUMENTS, INC.
89 Pearl Street, So. Braintree 85, Mass.
AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1939)

Circle 531 on Page 19



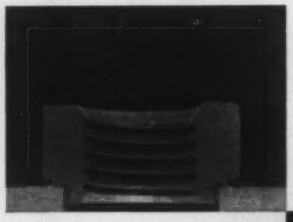
New SPS Swage Nuts can be installed quickly and easily in a wide range of sheet metals, including steel, without use of special tools or dies. They provide handy tapped holes in thin-section assemblies, aid in blind fastening.

New SPS Swage Nuts simplify problem of putting load-bearing threads in sheet metal

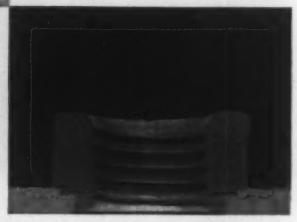
SPS Swage Nuts offer you a fast, economical means of putting load-bearing threads in thin metal. Unlike similar fasteners, they require no special tools, can be installed with a press fitted with flat dies. Further, they do not discolor, deform or buckle the metal in which they are mounted. And they do not project from the opposite side of the plate, a design advantage where minimum clearances are involved.

Push-out and torque-out values of SPS Swage Nuts are the highest available for fasteners of this type. This insures proper torquing of screws and increases reliability under working loads and vibration.

SPS Swage Nuts can be used in metal with a hardness up to approximately Rockwell C25. This is an advantage over comparable fasteners, because it includes steel, as well as the usual alloys of copper, Monel or aluminum. Swage nuts are available in sizes #2 through ½ in. (2B threads), with shank lengths for plate from .020 to .250 in. thick. For complete information, write for new Swage Nut bulletin (Form 2447) and samples. Aircraft/Missiles Division, STANDARD PRESSED STEEL Co., Jenkintown 18, Pa.



Step 1. Enlarged cross-section shows #8-32 SPS Swage Nut inserted in hole ready for swaging into plate. Ordinary hydraulic or pneumatic presses—even portable rivet setters—serve satisfactorily as installation equipment.



Step 2. Pressure displaces metal around edge of hole, forcing it into retaining groove. Swage ring knurls increase resistance to torque-out, also provide relief for metal flow. Note smooth surface on bottom of plate.

HIGH RELIABILITY

SPS research is continually developing fasteners with higher standards of predictable performance. By installing SPS high-reliability fasteners in your assemblies, you increase overall product reliability.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

suitable for recording running time of machinery, and in electrical and electronic equipment. Self-starting synchronous motors used are for 115 or 230-v, 60-cycle operation. Five-digit registers record total hours or hours and tenths, with white numerals on black backgrounds and tenth markings in red. **Marion Electrical Instrument Co.**, Grenier Field, Manchester, N. H. B

Circle 715 on Page 19

Cold-Drawn Steel Bars

have high brightness

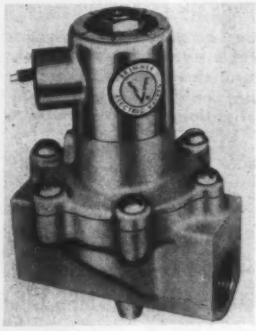
Cold-drawn steel bars are used for the manufacture of precision parts by machining. Superior brightness is advantageous when some part or all of original bar surface remains on finished part. Bars are supplied in rounds from 1/16 to 4-in. diam, in hexagon shapes from 1/8 to 3/16 in., in squares from 1/8 to 4 in., and in flats up to 6 in. wide. **Jones & Laughlin Steel Corp.**, 3 Gateway Center, Pittsburgh 30, Pa. F

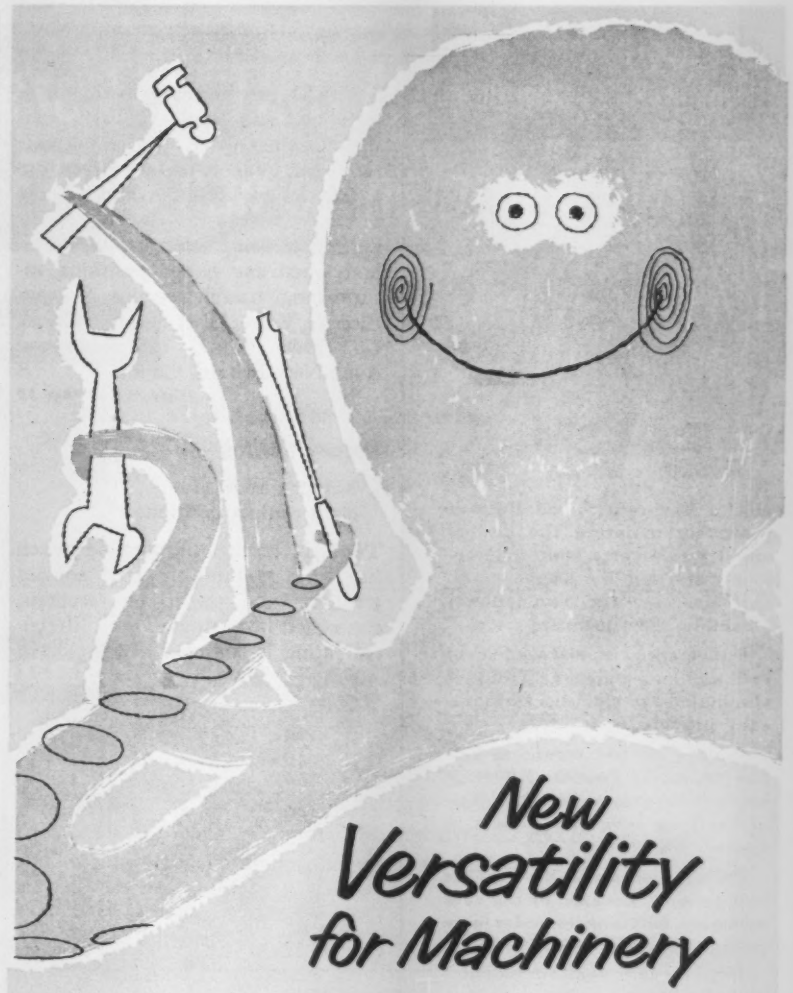
Circle 716 on Page 19

Two-Way Valves

operate on pressure differential of 5 to 150 psi

Series L high-flow, two-way valves with 3/4 and 1-in. diam orifices control air, oil, and water. They operate on a pressure differential of





New Versatility for Machinery

Changing production conditions demand versatility from your machinery. Sterling Speed-Trol Variable Speed Drives economically compensate for present or future production variables and keep machinery operating consistently at a higher output. A Sterling Application Engineer will show you how the versatile Speed-Trol Variable Speed Drive can deliver top production under changing conditions.

INQUIRE TODAY

STERLING ELECTRIC MOTORS

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LOS ANGELES 22 • CINCINNATI 12
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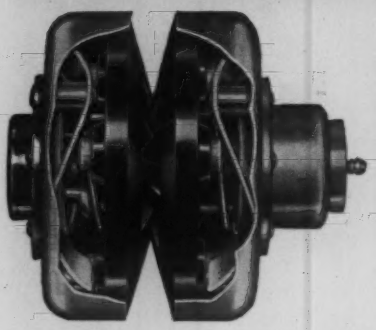
Speed-Trol Variable Speed Drives | Sle-Speed Gear Motors | Constant Normal Speed Motors | Multi-Mount Speed Reducers

Circle 533 on Page 19

Hi-Lo Load-O-Matic Control Eliminates Pulley Slow Down



Hi-Lo Variable Speed Pulleys positively maintain the desired speed ratio over a wide range of load variation by means of an exclusive cam and cam follower assembly. This means:

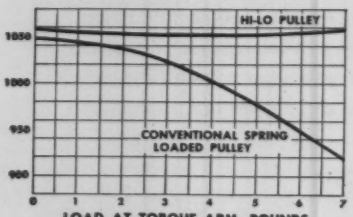
Pulley speed is independent of load and load changes. "Drag" is eliminated and high shock absorbency provided.

Pulleys do not compress belt due to spring pressure. Springs are not driving members. They act only to keep pulley faces in contact with belt.

Pulleys automatically regulate belt tension. Because of the cam assembly, belt is never under more tension than required by the load.

Double cams maintain constant belt alignment.

HI-LO PULLEYS COMPARED TO OTHER VARIABLE SPEED PULLEYS



LOAD AT TORQUE ARM, POUNDS

PLUS THESE OTHER FEATURES:

- Smaller in size than comparable units.
- Quickly and easily installed.
- Replaceable face assemblies drastically cut repair and replacement costs.
- Available in sizes from .5 to 5 hp., ratios to 2.5/1 (single pulley) 6.25/1 (double pulley).

Request details and prices. Ask for Bulletin A-458.

Manufactured By HI-LO MANUFACTURING COMPANY

Nationally Distributed By LOVEJOY FLEXIBLE COUPLING COMPANY
4968-H W. Lake St
Chicago 44, Ill.

Circle 534 on Page 19

5 to 150 psi, and are available in standard and explosionproof construction, normally open or normally closed. Valves mount directly to a line in any position and can be serviced without removal. A diaphragm, completely supported in both open and closed positions, assures long, troublefree life. **Skinner Electric Valve Div., Skinner Chuck Co.**, Dept. L141, 105 Edgewood Ave., New Britain, Conn. B

Circle 717 on Page 19

Rotary Switch

has maximum of eight contact positions

Type JL rotary multiple-pole switch has a maximum of eight contact positions and up to ten sections, controlled by a single knob. Electrical rating is 5 amp 125 v ac. Each

section of the switch contains a rotor with movable contact that engages stationary terminals inside insulating walls of a molded disc. Rotor movement can be unlimited in either direction, or limited to any number of eight positions by placement of two stop screws in rear plate of switch. **Electro Switch Corp.**, 167 King Ave., Weymouth 88, Mass. B

Circle 718 on Page 19

Adjustable-Speed Drive

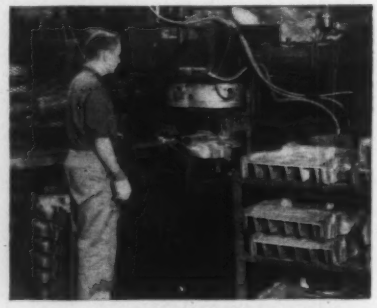
in ratings from 1 to 20 hp at speeds of 1 to 10,000 rpm

Allispede mechanical adjustable-speed drive provides infinitely adjustable speed over ranges up to 8:1. Drive operates from an ac power source and is available in ratings from 1 to 20 hp with output speeds of 1 to 10,000 rpm. Basic components can be rearranged in the field to meet changing requirements. Units can be mounted ver-

MONARCH EXPLORATORY ENGINEERING

...a new freedom for creating better end-products within production budgets

Many ideas about what can or cannot be accomplished with castings are now obsolete. Monarch exploratory engineering in finishes, surface texture, metallurgy and production methods has opened new design horizons.



Consult with Monarch engineers, on your current product or new project. They will bring you their wide experience in casting design, surface treatments and mass-production techniques that have been successfully applied to many outstanding products.

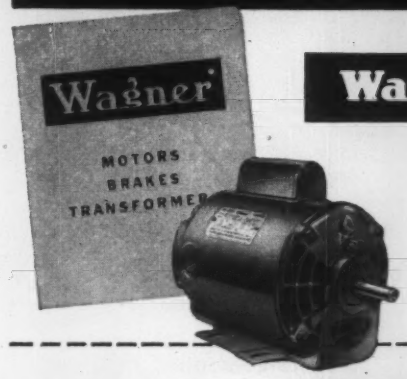
You can profit through Monarch's advanced technology. Monarch engineering consultation is available to you without obligation. Call or write today.

MANUFACTURING in MOLTEN ACHIEVEMENTS ALUMINUM

MONARCH ALUMINUM MFG. COMPANY
9205 Detroit Avenue Cleveland 2, Ohio

Circle 535 on Page 19

Which of these ELECTRIC MOTOR BULLETINS can be helpful to you?

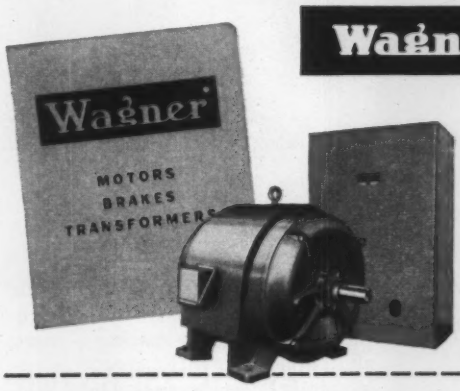


Wagner FRACTIONAL HP MOTORS

Bulletin MU-211. Illustrates and describes both single-phase and polyphase squirrel-cage motors, open and enclosed types; also fan and blower motors and jet pump motors.

Wagner INTEGRAL HP MOTORS

Bulletins MU-212, 213. Cover single-phase ratings through 15 hp, and polyphase squirrel-cage motors through 1000 hp, open and enclosed types; also multispeed, punch press, crane and hoist, and wound rotor polyphase motors.



Wagner MOTOR-STARTER COMBINATIONS FOR REDUCED CURRENT STARTING

Bulletins MU-124, 128, 195. Illustrate and describe the Wagner part-winding motor and starter combinations that limit inrush of starting current in squirrel-cage motors up through 500 hp—meet all starting requirements of AEIC-EEI-NEMA.

In addition to a complete line of standard motors, Wagner also furnishes tube ventilated motors through 500 hp, vertical and flange mounted motors, hermetic motors, gear motors, and direct-current motors. Consult the nearest of our 32 branch offices, or write for specific information on these special application motors.

WM58-15

MAIL COUPON TODAY...
FOR ANY OR ALL OF THESE BULLETINS

Wagner Electric Corporation
6404 Plymouth Ave., St. Louis 14, Mo.

Please send me the following Electric Motor Bulletins:

- ☐ MU-211 Fractional hp Motors.
- ☐ MU-212, 213 Integral hp Motors.
- ☐ MU-124, 128, 195 Reduced Starting Current Combinations.
- ☐ MU-185 All the above material in a single binder.

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COMPANY_____

ADDRESS_____

CITY & STATE_____

Circle 536 on Page 19

SEALING DOMESTIC APPLIANCES IS A REAL CHALLENGE, TOO!
Standard 6A Seal with specially designed seat conforming to impeller contour so as to promote good water flow characteristics.
Limited axial room and large diameter are mechanical requirements in this washing machine seal. Design features multiple spring construction for even face loading.
FIVE ADAPTATIONS OF THE John Crane
TYPE 6A SEAL
for four different appliance manufacturers
Seal features outer periphery face construction to best service garbage disposal conditions.
Two sealing points in a washing machine with widely differing physical limitations, yet seals for both retain full advantage of diaphragm action, shouldering points and positive drive.

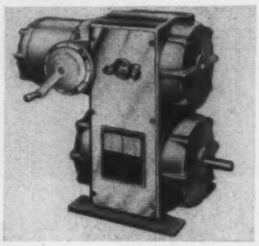
Soapy water, detergents, bones, grit and lint . . . all these combine to make appliances a hard-to-handle sealing problem. Add that to a very limited space factor, and you've got a real set of conditions on your hands.

"John Crane" engineers have solved these problems and thousands of other shaft sealing applications on all types of commercial and industrial equipment. We know that we can be of the same help to you.

That's why . . . as one design engineer to another . . . we urge you to let us work with you in adapting or developing the proper seal for your application.

Tell us about your requirements or write for our fully illustrated Bulletin S-204-3 on "John Crane" Shaft Seals.

Crane Packing Company, 6425 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). *In Canada: Crane Packing Co., Ltd., Hamilton, Ont.*



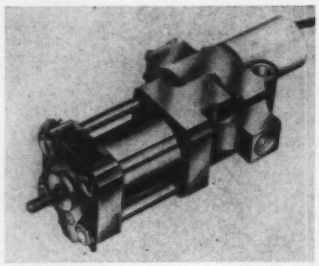
tically or horizontally on floor, wall, or ceiling. Output shaft and motor can be located in any of four positions, and location of speed-changing mechanism can be on top, right, or left of motor housing. **Louis Allis Co.**, Dept. P, 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 719 on Page 19

Solenoid-Controlled Actuator

has low leakage with light gases

New solenoid-controlled actuator package for pneumatic and hydraulic applications has very low leakage, even with helium. Model 106-2 (shown) has a pressure range of 50 to 750 psi and temperature range from −80 to 275 F continuous duty. Other models handle pressures to 3000 psi and withstand continuous-duty temperatures to 500 F. Unit shown has port-size listing



of AND 10050-4, stroke of 1.6 in., and rod diam of 5/16 in. Weighing only 1.7 lb, package meets all applicable MIL specifications. **Waldorf Fluid Systems Div., Waldorf Instrument Co.**, Huntington Station, N. Y. D

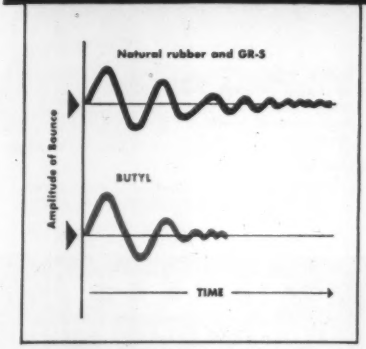
Circle 720 on Page 19

Solenoid Valves

for ambient temperatures from −20 to 200 F

New two and three-way solenoid valves are designed for air, oils, water, and gases. Valves operate at

BEST WAY TO ABSORB SHOCK!



Butyl's superior shock absorption characteristics reduce amplitude of bounce in much less time as compared with other rubbers.

Enjay Butyl, because of its higher damping factor, absorbs shock energy *more* completely than any other rubber. Through simple variations in compounding or processing, you can build the right degree of resiliency for your requirements. Butyl is the ideal rubber for motor mounts, load cushions, sound deadener insulation, axle and body bumpers—and other shock, noise and mechanical vibration applications.

Butyl *also* offers outstanding resistance to weathering and sunlight . . . chemicals . . . heat . . . abrasion, tear and flexing . . . unmatched electrical properties and impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

ENJAY® BUTYL

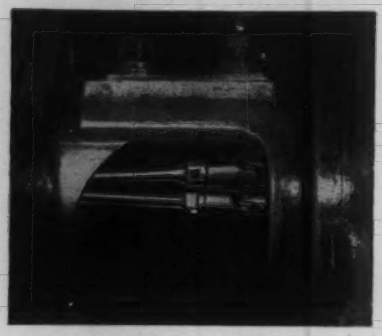
ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

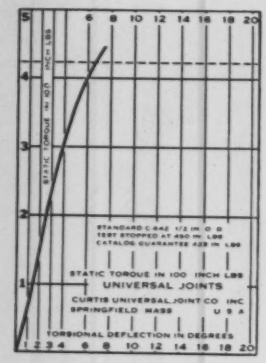
Circle 538 on Page 19

Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.


STATIC TORQUE IN 100 INCH LBS
UNIVERSAL JOINTS
CURTIS UNIVERSAL JOINT CO. INC
SPRINGFIELD MASS U S A
TORSIONAL DEFLECTION IN DEGREES

Torque Curve ½" Curtis Universal Joint

This is only one of many problems solved by Curtis Joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, and over 30 years' experience manufacturing universal joints make them that way.

14 SIZES ALWAYS IN STOCK —
⅜" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

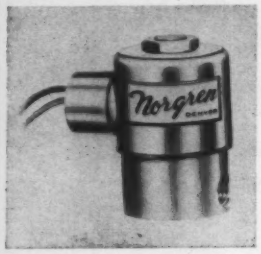
UNIVERSAL JOINT CO., INC.

5 Birnie Avenue, Springfield, Mass.

As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 539 on Page 19



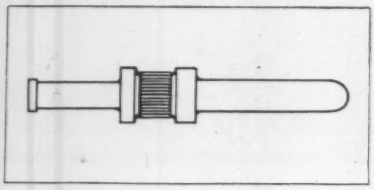
ambient temperatures from −20 to 200 F and media temperatures of −20 to 175 F. All valves operate in any position. Series A is available in ⅛ and ¼-in. pipe sizes, and includes two-way (shown), three-way, and directional solenoid valves in both normally closed and normally open types. Series B is a midget, two-way, normally closed valve with ⅛-in. NPT ports. C. A. Norgren Co., 3400 S. Elati St., Englewood, Colo. K

Circle 721 on Page 19

Terminals

for molding or encapsulating

New terminals are designed for molding into plastic headers, especially for use in printed circuits and miniature tube sockets. Meeting MIL-E-1, units have 0.00002-in. flashing of gold over heavy silver plating, eliminating oxidation and assuring proper flowing of solder at elevated temperatures. Tolerances to ±0.001 in. are held to permit easy mold releasing, and knurled surfaces provide maximum



molded sections. Units are available in several sizes. Alpine Electronic Components Corp., Wolcott Road, Waterbury, Conn. B

Circle 722 on Page 19

Storage Tube

is used to store information in computers

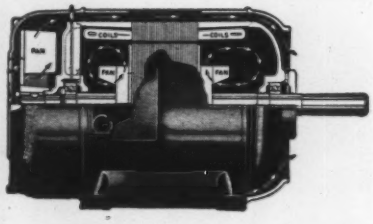
New 3-in. computer storage tube, designated WL-7225, receives information in the form of electrical impulses, stores it, and reads back

ELECTRIC POWER

AT IT'S MONEY SAVING

BEST . . !

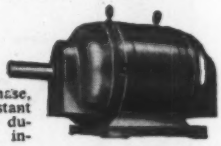
AIR COOLED



VALLEY *BALL BEARING* MOTORS

This completely enclosed but... air cooled motor is of the latest design—no foreign matter can penetrate the windings. Its ball bearings and stator core are kept cool by 3 fans which transfer the heat to the frame and end bells — cooling the motor completely — and remember a cool motor runs longer.

Other Types of Valley Motors



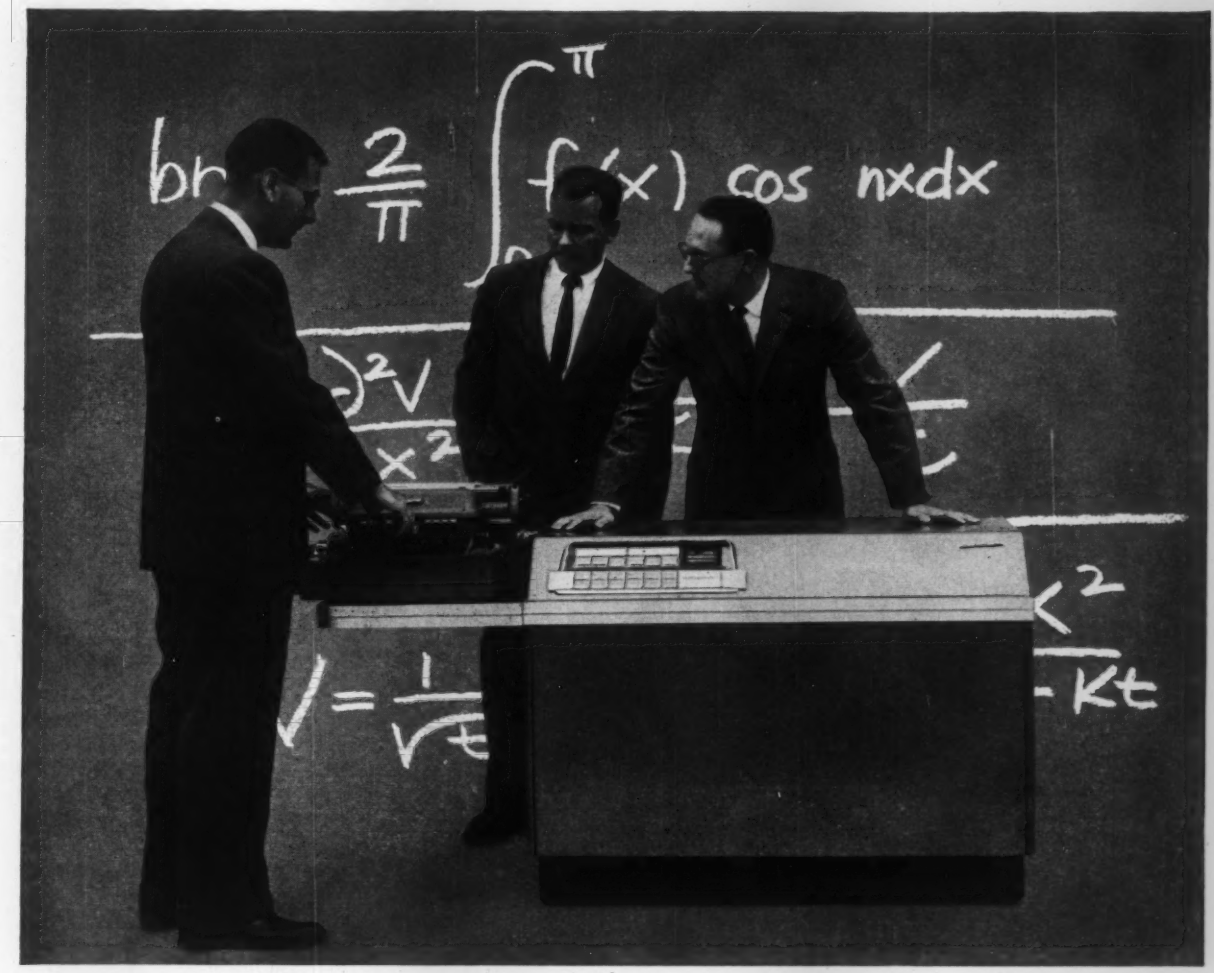
Type SN polyphase, high torque, constant speed, continuous duty, squirrel cage induction.

Type AN single phase, constant speed, continuous duty, repulsion start, induction run.

Write for Descriptive Literature.

VALLEY
ELECTRIC CORPORATION
4221 FOREST PARK BLVD. · ST. LOUIS 8, MO.

Circle 540 on Page 19



Speed routine calculations—increase creative time with this powerful electronic computer ROYAL PRECISION LGP-30

Large capacity... easily programmed and operated... mobile... low in cost

Compact, simple to use, Royal Precision LGP-30 will today bring high-speed computation *right to your desk* ... thus relieve you of the tedium of standard hand calculations... increase available time for truly creative work... help you simulate optimum designs in a matter of minutes. And at the lowest cost ever for a complete computer system!

Unusual capacity. Operating from a standard wall outlet, performing an almost unlimited range of calculations, LGP-30 gives you the flexibility of stored-program operation combined with speed, memory (4096 words) and capacity equal to computers many times its size and cost. Completely mobile, LGP-30 is easily wheeled from room to room, building to building.

Simple to operate and program. LGP-30 controls have been so thoroughly simplified that it may be operated with only minimum computer experience. Direct print-out of answers – no deciphering required. Programming is easily learned—even by non-technical personnel. Library of sub-routines, plus programs for a wide variety of applications, is available.

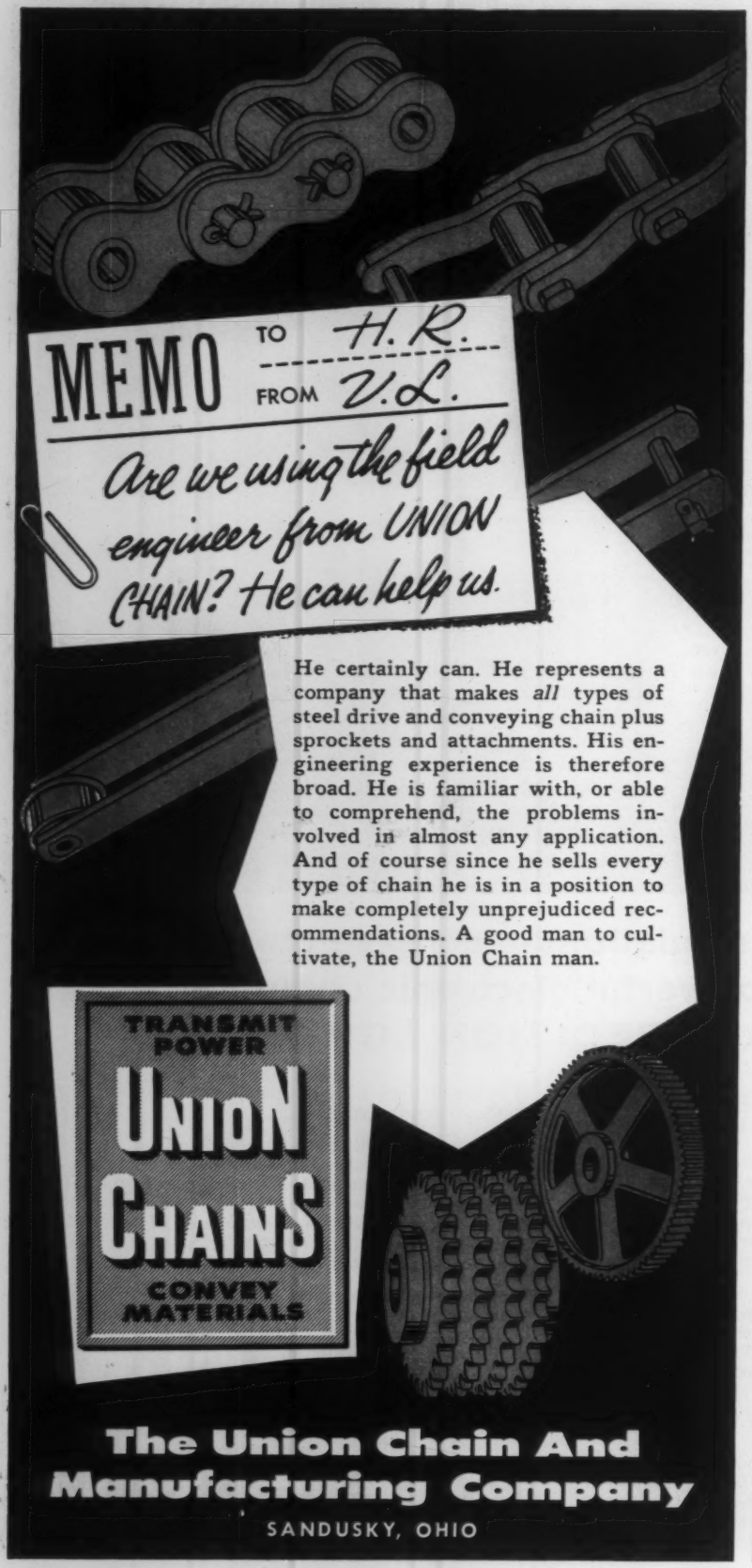
Wide range of applications. In addition to general design and system optimization, LGP-30 is currently being used for the refinement of estimates; computation of design parameters; specification of new product properties and capabilities; calculation of such data as reactance, load saturation curves, time constants, harmonics, torque-speed and vee curves.

Exceptional value; complete service. Smallest initial investment ever for a complete computer system is combined with low operating and maintenance costs. Service facilities coast-to-coast.

For further information and specifications, write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.

ROYAL McBEE
data processing division

Circle 541 on Page 19


MEMO TO H.R.
FROM V.L.
Are we using the field engineer from UNION CHAIN? He can help us.
He certainly can. He represents a company that makes all types of steel drive and conveying chain plus sprockets and attachments. His engineering experience is therefore broad. He is familiar with, or able to comprehend, the problems involved in almost any application. And of course since he sells every type of chain he is in a position to make completely unprejudiced recommendations. A good man to cultivate, the Union Chain man.
TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO

electrically the accumulated information. Unit has a 2.6-in. diam of useful target and electron gun beam focusing to a fine spot. Con-

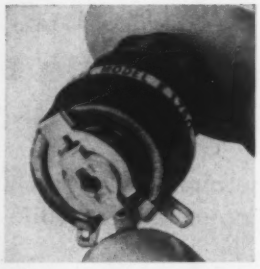
ventional coaxial connector for output terminations makes possible a compact mounting. **Electronic Tube Div., Westinghouse Electric Corp.,** P. O. Box 284, Elmira, N. Y. D

Circle 723 on Page 19

Miniature Rheostat

dissipates 12½ w at 40 C

Model E miniature rheostat is a ceramic and metal unit only 7/8 in. in diam and extending 11/16 in. behind mounting panel. It is capable of 12½ w dissipation at 40 C. Unit has ceramic hub, independent contact-arm pressure, and vitreous enamel coating. Capable of operation in high ambient temperatures, with proper derating, unit lends itself to military and aircraft applications. There are 23



different resistance values available with linear winding. Rheostats with nonlinear taper, tandem rheostats, or other features can also be provided. **Ohmite Mfg. Co.,** 3698 Howard St., Skokie, Ill. J

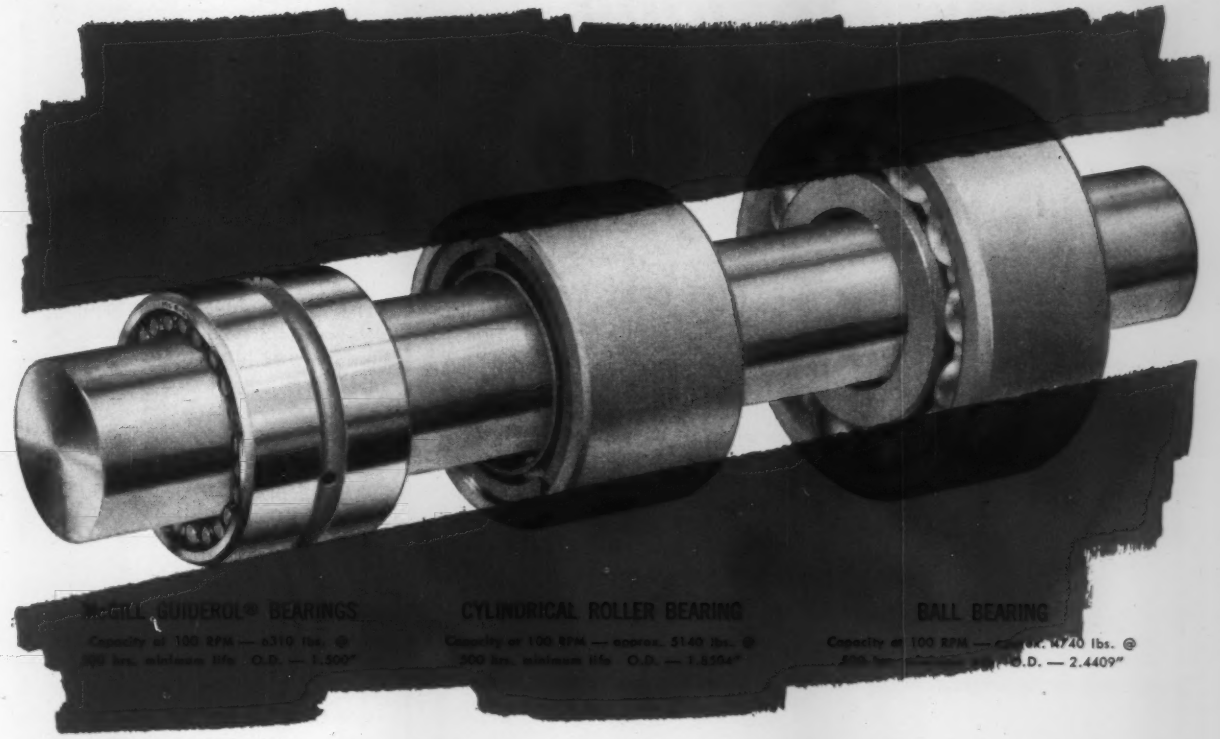
Circle 724 on Page 19

Solenoid and Pilot Valves

three-way units
share same type base

New three-way solenoid and three-way pilot valves use same type base and have same operating parts, permitting fast interchangeability

Circle 542 on Page 19

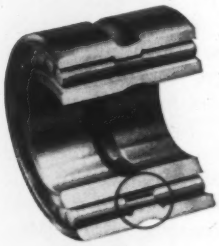


GUIDEROL® BEARINGS SAVE RADIAL SPACE

. . . . . and still offer greater load capacity

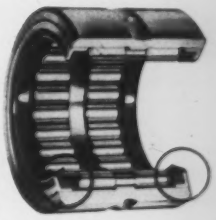
This graphic illustration demonstrates the radial space saving advantages of McGill GUIDEROL bearings that offer still greater capacity than the other two types of bearing compared. For a common 1" shaft, the GUIDEROL bearing GR-16 has an O.D. of only 1½" with a capacity of 6310 lbs. Compared to a cylindrical type roller bearing the GUIDEROL bearing requires ⅜" less housing space and offers 23% more capacity. A ball bearing for the same shaft uses almost an inch larger O.D. to carry 1500 lbs. less radial load.

CENTER GUIDED ROLLERS



GUIDEROL bearings pack more performance into smaller radial space. Their construction offers the inherent high capacity of a full complement needle bearing combined with effective roller control. Center guided rollers limit roller skewing tendencies and prevent binding under adverse conditions in either horizontal or vertical mountings. This qualifies GUIDEROL bearings for applications which are too heavily loaded for retainer type needle bearings, but are subject to misalignment that precludes the use of unguided needle bearings. Standard GR series GUIDEROL bearings are available, with or without inners, in shaft sizes from ⅝" to 9¼" with capacities ranging from 2880 lbs. to 128,670 lbs. (at 100 RPM).

LUBRICATION LOCKED IN, CONTAMINATION OUT; IN SEALED GUIDEROL BEARINGS



Pre-lubricated and sealed SG series GUIDEROL bearings are interchangeable dimensionally with standard GR series GUIDEROL bearings. They offer 5 possible seal combinations. Specify the sealed bearings for applications that are exposed to dust, dirt, grit or where accessibility for lubrication is a problem. Your McGill representative will be happy to assist you with special application problems. Ask him for recommendations or write the McGill Engineering Department.

For Complete Data on Dimensions, Capacities and Application of McGill Precision Needle Bearings, Send for Free Catalog No. 52A.

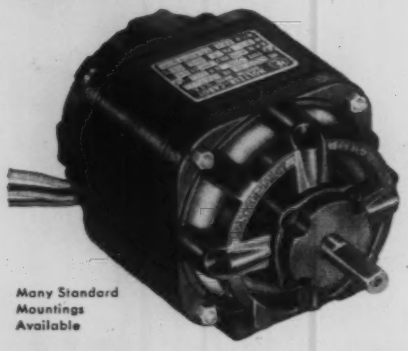
engineered electrical products

McGILL®

precision needle roller bearings

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 NORTH LAFAYETTE ST., VALPARAISO, INDIANA

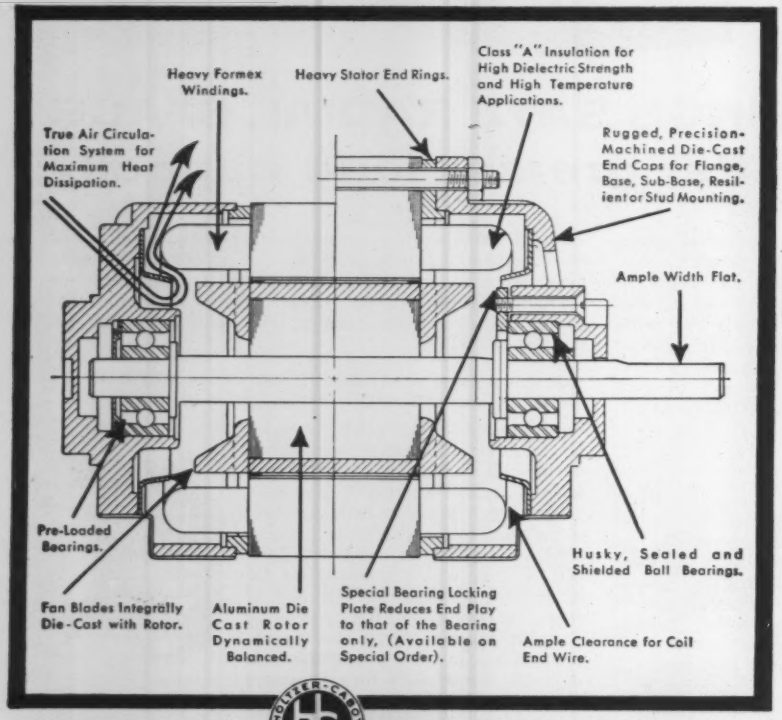
New Designs in Motors from HOLTZER-CABOT



Many Standard Mountings Available

TYPE R-29 MOTOR
2⅞" Diameter

This motor is an ideal power source for recording instruments, timers, medical instruments, office equipment, blowers, tape recorders, communications equipment, etc. It is available in both 2-pole and 4-pole design, each in three stacking lengths. Type R-29 is a permanent split capacitor type available as an induction or synchronous motor. H.P. of various models ranges from 1/75 to 1/30. Construction features are indicated below.

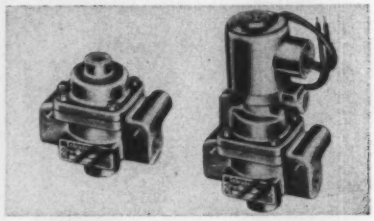

Heavy Formex Windings.
Heavy Stator End Rings.
Class "A" Insulation for High Dielectric Strength and High Temperature Applications.
True Air Circulation System for Maximum Heat Dissipation.
Rugged, Precision-Machined Die-Cast End Caps for Flange, Base, Sub-Base, Resilient or Stud Mounting.
Ample Width Flat.
Pre-Loaded Bearings.
Husky, Sealed and Shielded Ball Bearings.
Fan Blades Integrally Die-Cast with Rotor.
Aluminum Die Cast Rotor Dynamically Balanced.
Special Bearing Locking Plate Reduces End Play to that of the Bearing only, (Available on Special Order).
Ample Clearance for Coil End Wire.

For more information, write, or use Readers' Service Card.

Sales — Service Representatives in Principal Cities throughout the World

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston, Massachusetts

Designers and manufacturers of mechanical, pneumatic, hydraulic, electric and electronic equipment and systems

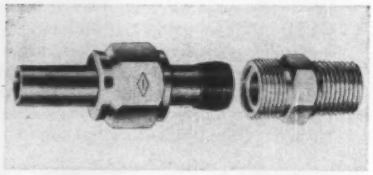


and minimum requirement for spare parts. Pilot valve can be converted to a solenoid type by replacing pilot chamber with solenoid head, and vice versa. Pilot of solenoid valve can be converted from a normally open to a normally closed type by shifting pilot or solenoid chamber head 9 deg. Both valves are heavy-duty type with high flow capacities and range of air pressure from 20 to 150 psi. Available voltages are 12, 110, 220, and 440. Five thread sizes range from ¼ to 1 in. on both valves. Valves are easily mounted through side bases. Poppet-type design of both permits maximum air passage with air moving freely for less pressure drop. **A. Schrader's Son Div., Scovill Mfg. Co.**, 470 Vanderbilt Ave., Brooklyn, N. Y. C

Circle 725 on Page 19

Flareless Tube Fitting

brass unit makes a butt joint



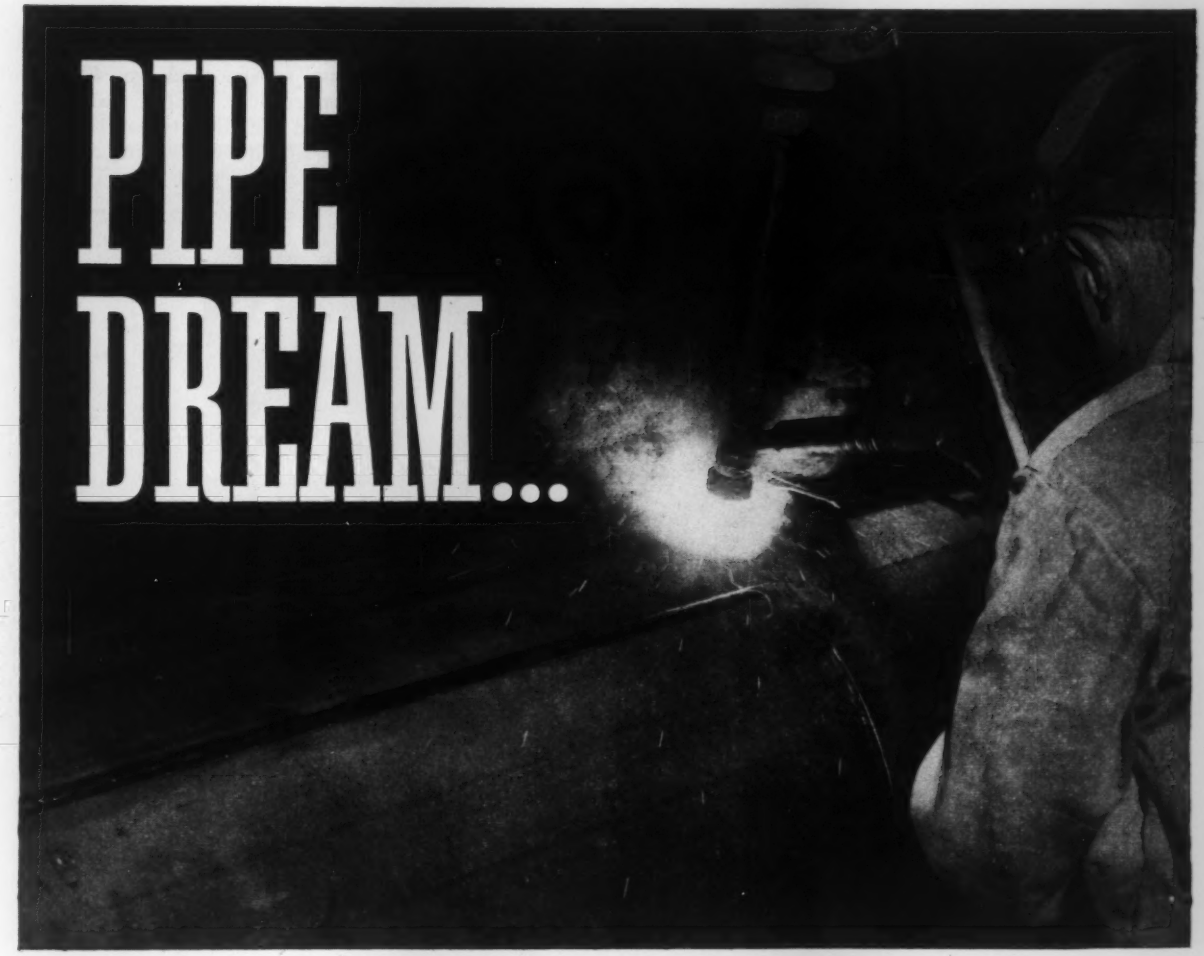
Hi-Seal brass flareless tube fitting makes a butt joint, with no tube entry into throat of fitting, so that there is no need to spring tubing in making connections. Sleeve can be put on in only one direction. Closer tube bends are possible, and there is greater tolerance in tube length and tube placement to speed installation. **Imperial Brass Mfg. Co.**, 6300 W. Howard St., Chicago 48, Ill. J

Circle 726 on Page 19

Germanium Rectifiers

have snap-in design

Snap-in germanium rectifiers are available in two sizes—one 400-ma



...UNIONARC Welding saves $7000 on one production run

UNIONARC Welding—LINDE's new electric welding method for steel—increased production by 300% and saved a western pipe mill $7000 on a single run of steel pipe. Replacing covered electrode methods, UNIONARC Welding is expected to save this company $150,000 a year.

UNIONARC Welding uses a continuously-fed wire electrode, magnetically coated with flux and shielded with carbon dioxide gas. It has three times the speed and weld penetration of covered electrode welding. And UNIONARC Welding gives you "finished", X-ray quality welds and low hydrogen deposits—in all welding positions.

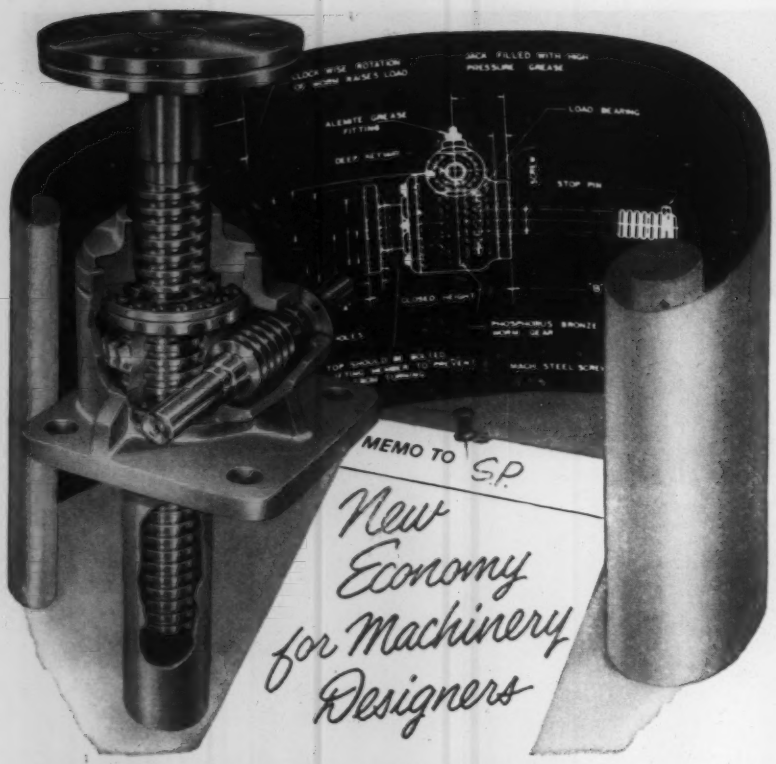
See for yourself—ask your nearest LINDE representative to *prove* that UNIONARC Welding slashes time and labor costs over conventional methods. Call your local LINDE office today! Or write Box Q112, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde TRADE-MARK

UNION CARBIDE

"Linde", "Unionarc", and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle 545 on Page 19



NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

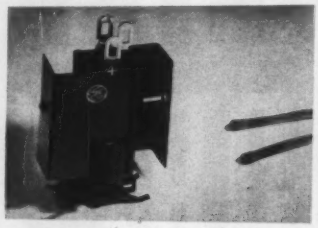
DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever
Hand Chain, Electric

Circle 547 on Page 19

halfwave rectifier and one 400-ma doubler rectifier. Both rectifiers, designated JETEC types 1N1008 and 1N1016, deliver 400-ma dc output into a load at 70 C or 158 F.



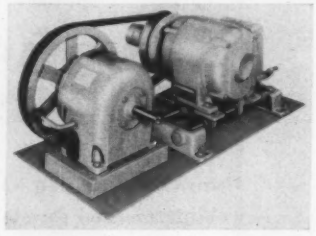
Both devices are rated at peak inverse voltage of 380 v and rms input voltage of 130 v. **Semiconductor Products Dept., General Electric Co.**, Syracuse, N. Y. C

Circle 727 on Page 19

Adjustable-Speed Drive

uses four-speed geared transmission

New adjustable-speed drive is powered by an 1800-rpm electric motor with self-adjusting variable-pitch pulley on motor shaft, and belted to a companion pulley on four-speed transmission input shaft. It is available in eight horsepower ratings from ½ to 7½ hp Assembly is furnished in several different mo-



tor and transmission combinations to provide speed variations from 12:1 to 25.7:1. Units have applications on many types of machines. **Lima Electric Motor Co. Inc.**, Dept. 139, Lima, Ohio. G

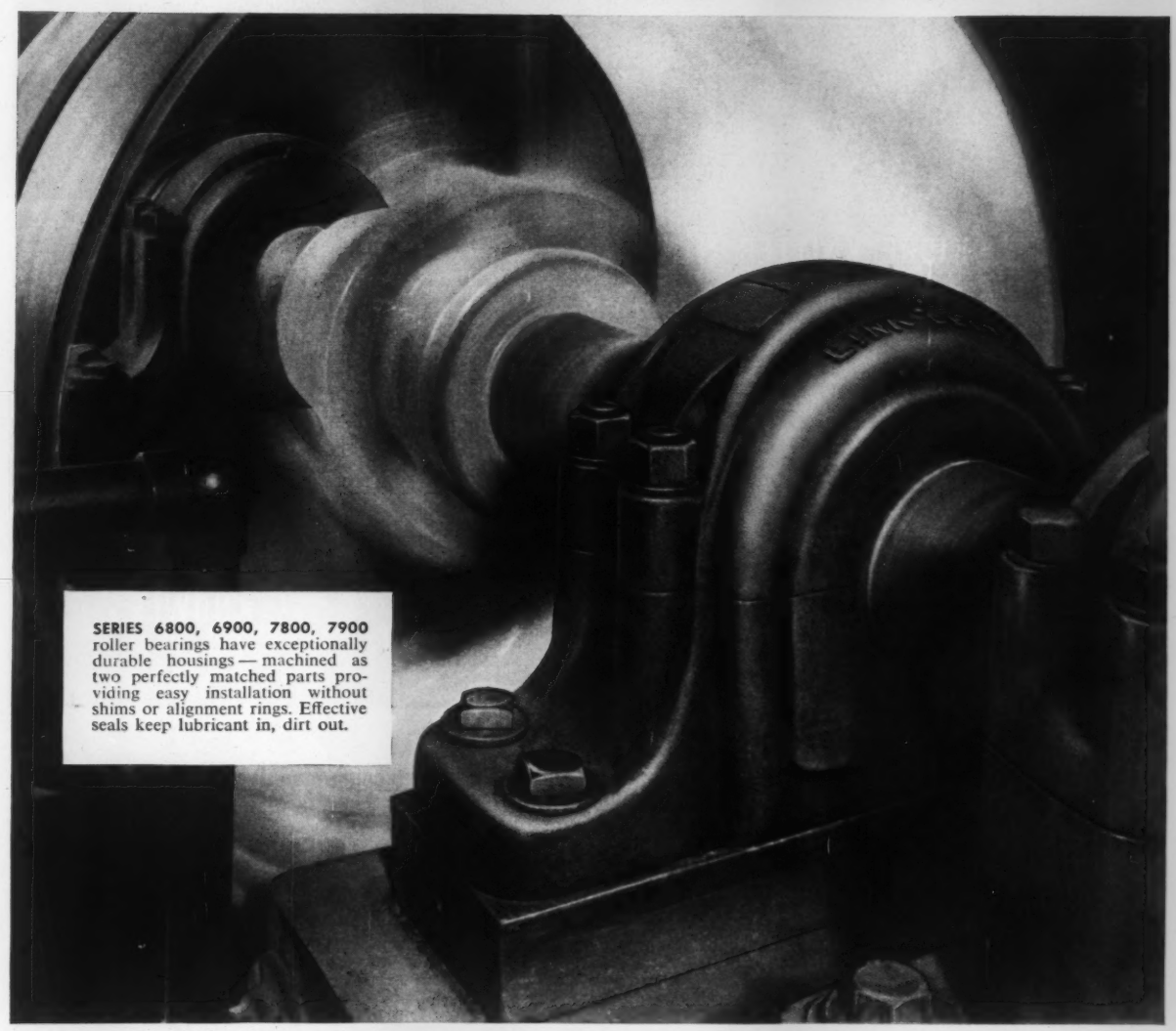
Circle 728 on Page 19

Single-Suction Pump

for handling costly or volatile liquids

Electri-Cand single-stage, single-suction pump provides leakless handling of all costly or volatile liquids at temperatures to 200 F. Pump is available in capacities to 500 gpm at heads to 250 ft. Unit in ¾ to

NO PINCH, NO BIND-- ALWAYS-ALIGNED

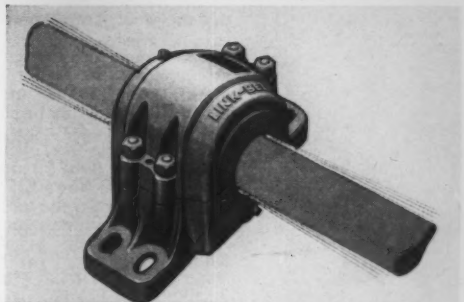


SERIES 6800, 6900, 7800, 7900 roller bearings have exceptionally durable housings — machined as two perfectly matched parts providing easy installation without shims or alignment rings. Effective seals keep lubricant in, dirt out.

These husky bearings in husky housings adjust *instantly* to shaft misalignment

Shaft deflection often means quick failure for ordinary bearings . . . but not for these rugged Link-Belt *self-aligning* bearings. Adjusting immediately in any direction, they easily compensate for misalignment . . . avoid damaging "pinch" and bind.

You can get full information on Link-Belt's complete bearing line from any one of 40 Link-Belt offices.

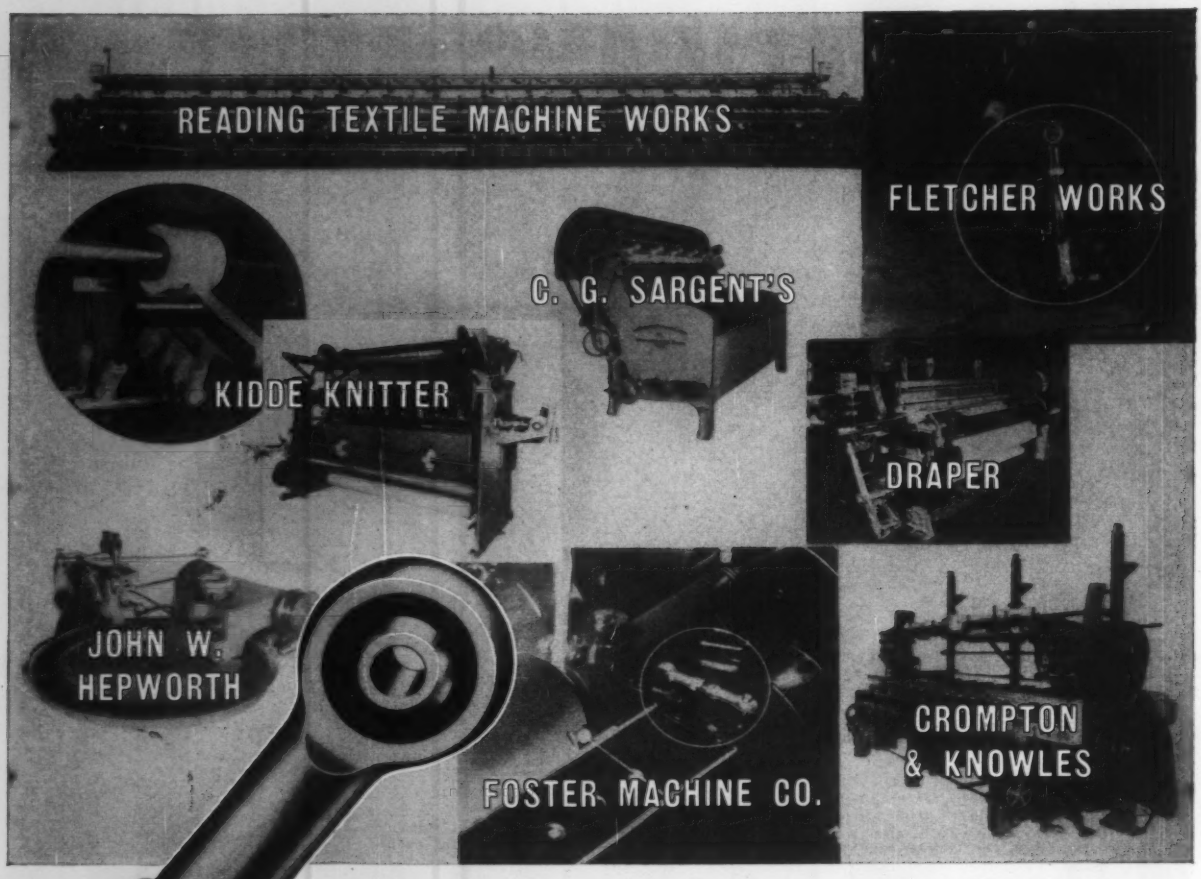


Spherical bearings are free to align in any direction, assuring full load capacity regardless of shaft deflection.

LINK-BELT

MANUFACTURERS OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 14,905-A



Label loom, Knitting machine, Coning machine, Loom Manufacturers specify . . .

HEIM *Unibal*® SPHERICAL BEARING ROD ENDS

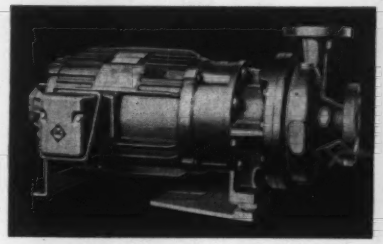
The textile industry has found literally hundreds of uses for the versatile Unibal Rod Ends. They correct inherent misalignments on the *Crompton & Knowles* Narrow Fabric Loom. On the *Draper* X-2 loom, one Unibal now takes the place of several parts formerly used. *Fletcher* uses Unibal to correct misalignment in the shuttle motion of a label loom. The *Foster* Pineapple Coning Machine uses Unibal for flexibility, freedom of motions, and ruggedness to withstand vibration. The *Hepworth* Sweater-Looper uses Unibal at both ends of all drive rods. The *Kidde* Knitter which produces lace edgings, veilings, etc. uses Unibal Rod Ends as suspension hangers. Unibal is used in the covering knife motion on the *Reading* Full-Fashion knitting machines. On the *C. G. Sargent* Automatic Feeder which combs out the wool, Unibal improves the operation of the driving mechanism.

The common function of all push-pull rod assemblies is the transmission of force and motion from one machine component to another. A Heim Unibal rod end at one or both ends of the rods in an assembly assures smooth, trouble-free operation. The Unibal device can be used for many other mechanical functions, however, and its versatility makes it a welcome accessory in solving many difficult support problems, such as the suspension hangers as used on the Kidde Knitter.

Unibal has only four components — the ball, the outer member, and the two bronze raceways. This simple construction offers smoothness, strength, greater load capacity, and the very useful ability to correct misalignment.

Heim bearings are sold through the country's leading bearing distributors. Write for complete catalog and/or engineering help.

THE HEIM COMPANY
FAIRFIELD, CONNECTICUT



1½-hp range is constructed on fractional-motor frame, and pump from 2 through 15 hp on an integral-motor frame. Pump requires neither mechanical seal nor packing. Carbon sleeve bearings are used in motor. Thin-wall stator cam passes from pump casing through air gap of motor to rear housing, sealing off stator-core iron and windings from pumped liquid. Pump and motor are a single integrated unit. The airtight unit is not subject to external conditions or atmosphere. **Allis-Chalmers Mfg. Co.**, P.O. Box 512, Milwaukee 1, Wis. K

Circle 729 on Page 19

Teflon-Lined Hose

is available up to 3 in. diam

Flexible Teflon-lined hose, designated Flexlon, is now available in diameters up to 3 in., permitting many more applications where formerly rigid alloy-metal or glass pipe was used. Hose withstands temperatures up to 325 F, depending on size and construction, all known chemicals except fluorine gas, chlorine, trifluoride, and molten alkali metals. **Manhattan Rubber Div., Raybestos-Manhattan Inc.**, Passaic, N. J. C

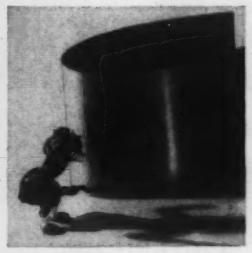
Circle 730 on Page 19

Terminal Blocks

for computer applications and printed circuitry

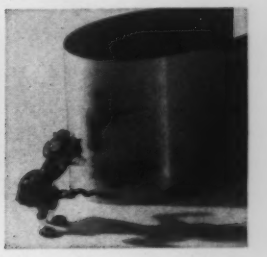
Solderless terminal blocks in single, dual, and triple-row units have been designed for various computer applications and for printed circuitry. They accept standard AMP 53 solderless taper pins and are available in any combination of feed-through individual or shorting terminals. External wiring has been eliminated by completely protected, molded-in internal bus connections between any combination of ter-

No matter which *FINISH* you like—you can buy it in *Micro Rold*® QUALITY STAINLESS STEEL



2D—A silvery white, but non-lustrous, surface produced by annealing and pickling cold reduced material. Steel sheets and strip in this condition are most ductile and the surface holds lubricant well for severe drawing operations.

2B—Steel in the 2D condition which is subsequently rolled on a "skin pass" or temper mill. The surface acquires a bright finish from the polished rolls. This surface is somewhat more dense and hard than 2D and is a better starting surface for later finishing and buffing operations.



No. 3—This surface is made by grinding with a No. 100 abrasive. This surface is smooth but not as reflective as 2B.

No. 4—A finer finish than No. 3 made by grinding with a No. 150 abrasive. Like No. 3, this surface is easily blended with hand grinders after forming, drawing or welding.

No. 7—Good reflectivity and brilliance made by polishing with a No. 400 abrasive. This semi-mirror finish must be protected during fabrication by adhesive paper or strippable plastics lest the finish be marred beyond repair.

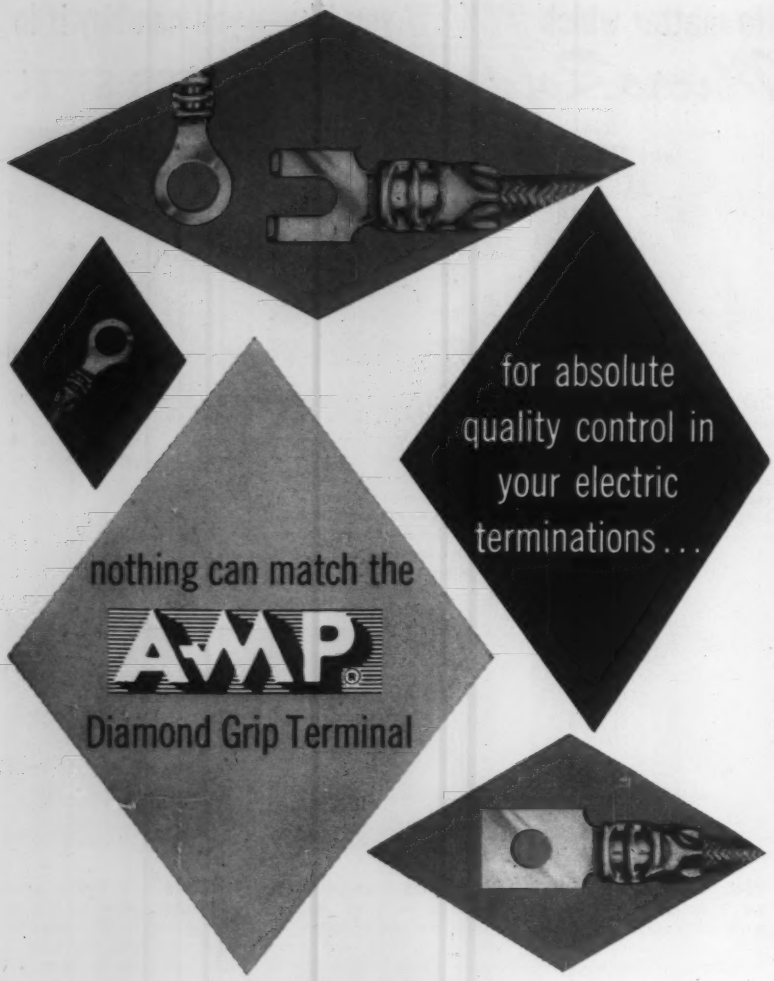
BRIGHT—A highly reflective surface made by cold reducing with highly polished, glass-hard rolls. This finish is only available in Type 430 stainless.

These are our standard surface finishes that are regularly supplied in all stainless grades (including 18-8 chrome-nickel and 430 straight chromium), with the exception of 430 Bright which is Type 430 exclusively. **These finishes are regularly supplied in sheet and coil form in widths up to 48 inches.** Since Nos. 3, 4, 7 and 430 Bright are smooth reflective surfaces, they are not recommended for severe drawing without special precautions as the mill finish may be marred. Applications such as dairy machinery, kitchen and restaurant equipment and architectural decorative work require only local forming, so these highly polished surfaces are not greatly disturbed. All mill polished sheets are carefully packed to avoid handling imperfections. Protective adhesive paper can be specified by the buyer when needed. For specific information on recommended surface characteristics for a particular stainless steel sheet and strip application, address your request to our Product Development Dept.

WASHINGTON STEEL CORPORATION

11-E Woodland Ave., Washington, Pa.

Circle 550 on Page 19



An endless parade of electrically perfect, wired terminals with absolutely identical performance characteristics is assured when A-MP non-insulated Diamond Grip terminals are used. No matter how many terminals you need, each action of the A-MP precision tool attaches a Diamond Grip terminal that gives firm, fully circumferential wire support, for maximum tensile strength, resists vibration and corrosion, while performing at maximum conductivity.

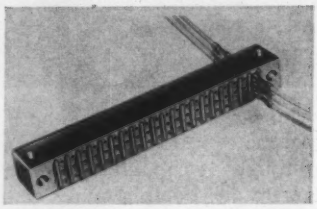
The reason for these never-varying features is the exact crimping operation which pressures the wire into one homogeneous mass and permanently bonds it to the terminal. Wire size range is from No. 26 to No. 10. Important, too, are the lower installed costs of Diamond Grip terminals when compared to other methods of wire termination.

No matter what your termination problem is, our engineering services are available to you anywhere in the free world.

For complete specifications, write for our Diamond Grip Terminal and Connector catalog.

AMP INCORPORATED
General Offices: Harrisburg, Pennsylvania
A-MP products and engineering assistance are available through wholly-owned subsidiaries in: Canada • England • France • Holland • Japan

minals. Holes are provided for stacking or right-angle and perpendicular mounting. Taper receptacles are brass, gold-plated over silver for low contact resistance and



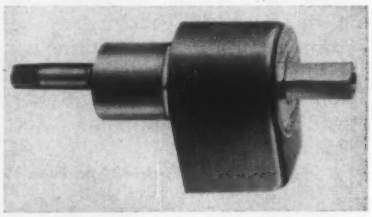
freedom from corrosion. Molding materials include melamine, diallyl phthalate, alkyd, and phenolic-mica. **Electronic Sales Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 731 on Page 19

Packless Solenoid Valve

is high-pressure, two-way unit

GV60-565 high-pressure, two-way packless solenoid valve controls air and gases to 2500 psi and liquids to 1800 psi. Valve body operating parts are stainless steel, and there are no stuffing boxes or sliding glands that require maintenance. Valve is suitable for low-temperature, high-pressure applications in missile ground-support and nuclear-control systems, in addition to general-purpose applications. It is avail-



able with NEMA I, IV, VII, IX, and IXA solenoid enclosures, ¼-in. NPT or AND connections, and standard, threaded, or AN electrical connections. **Automatic Switch Co.**, Florham Park, N. J. D

Circle 732 on Page 19

Heavy-Duty Engine

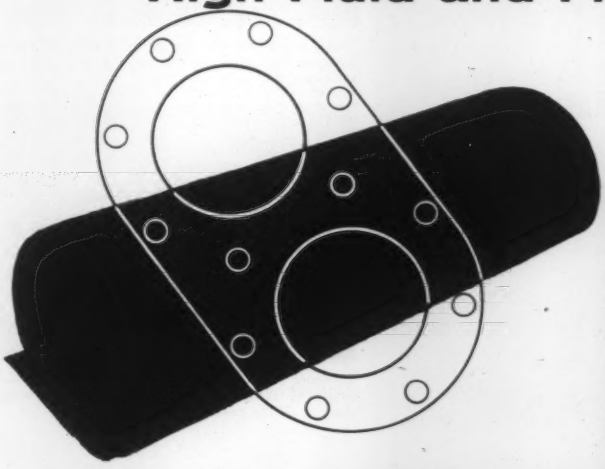
features low speed power take-off

Model K660CR heavy-duty engine is a short-stroke, four-cycle unit equipped with a combination clutch reduction assembly. Air-cooled, it is

Circle 551 on Page 19

VICTOPAC

Asbestos-Synthetic Rubber Gasketing Durable under Heat, High Fluid and Flange Pressures



Seals against oil, engine fuels (liquid or vapor) and coolants, steam, hot or cold water

Supplied in Sheets . . . or Finished Gaskets
Made in standard thickness:
1/64" — 1/32" — 1/16" — 3/32" — 1/8"

This tough, completely homogeneous sheet packing is composed of long-fiber asbestos and synthetic rubber, bonded under heat and pressure.

While thoroughly dense in structure, Victopac has sufficient compressibility for effective sealing under light or heavy flange loading. Its resistance to heat permits usage where plant fiber packings deteriorate.

CONDENSED SPECIFICATIONS

Type	SAE-ASTM Spec.	% Compression 5000 Psi. Load	Recovery %	Minimum Original Tensile	Max. Thickness Change in ASTM Oil No. 1— 5 hrs. at 300 deg. F.
1	G-1111-1 *P1161A	12±5	40	1800 psi.	20%
1B	G-1111-1 (Federal Spec. HH-P-46A *P1161A	12±5	40	1800 psi.	20%
2 Graphite coated, one side	G-1111-1 *P1161A	12±5	40	1800 psi.	20%
3 Graphite coated, two sides	G-1111-1 *P1161A	12±5	40	1800 psi.	20%
50V	G-1122-1 (AMS 3232F) (Navy Spec. 33-P-13c) *P1141A	12±5	40	2000 psi.	10%
60V	G-1123-1 (AMS 3230 and 3231) *P1151A	12±5	40	2000 psi.	15%
70V	G-1122-1 (AMS 3232F) *P1141A	12±5	40	2000 psi.	10%

*Latest ASTM No. D1170-58T, SAE No. 90R and MIL-G-12803A specifications.

Made in 7 types — Typical uses

Victopac is widely specified for automotive and industrial machinery applications. Choice of seven basic types provides economical sealing for each use. All types conform to SAE-ASTM specifications and are certified to federal, military or customer specifications where needed.

Typical applications include speed reducers, transmissions, differentials, gear case covers, pipe flanges, refrigeration, pumps, oil coolers, internal combustion engines, etc. Victopac's uses are almost unlimited.

Test samples supplied free

Your inquiry, stating proposed application, will bring you sample sheets of recommended type with full technical data. Request through your Victor Sales Engineer or directly to factory.

Victopac is available in sheet sizes 58" x 62½" and 58" x 125". Write for special price list.

Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ont.

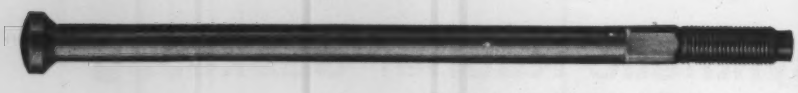
VICTOR

Sealing Products *Exclusively*

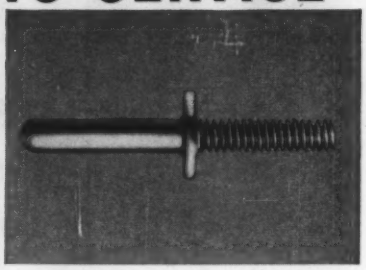
GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

Circle 552 on Page 19

National SPECIAL PRODUCTS SERVICE



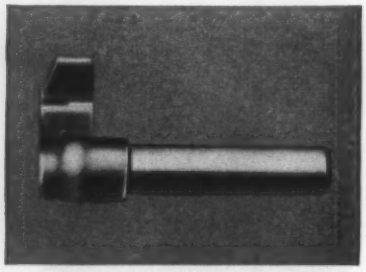
Precision parts with closely held tolerances and excellent surface finish, like this, can also be cold headed more economically and quickly.



Small parts like this can be produced, by cold heading, in huge hourly volume and at low unit cost.

Get strength at low cost with

COLD HEADED SPECIALS!



Intricate formations, like this, difficult or too costly by other methods, become routine production in the cold heading process.

You can make remarkable savings and get better parts in many cases by letting us duplicate and improve on parts you previously have had machined, cast or forged. It's possible with National cold heading!

What's more, we can quickly tell you whether cold heading would be an advantage for new designs.

Here's how National cold heading reduces unit costs . . . gives you better parts!

You save on production costs, because cold heading is fast . . . production rates of 50 to 300 pieces per minute are common. You don't pay for waste. Scrap loss in cold heading is negligible. You save on cost of extra operations, because cold heading eliminates them entirely or reduces their number. And most secondary operations, when required, can be performed automatically in mass production.

Cold heading assures strong, sound parts with good finish and excellent resistance to fatigue, shear and impact!

You're sure of strong parts because cold working *increases* the strength of steels and nonferrous metals. Subsequent heat-treatment or hardening can produce practically any degree of physical properties you desire.

You're sure of sound, clean parts because any defects, such as seams and inclusions, will open up in cold working . . . resulting in *automatic rejection.*

You're sure of superior fatigue, shear and impact resistance because cold heading produces continuous, unbroken flow lines in the grain of the metal . . . impossible to obtain by any other method.

You're sure of good surface finish, with a maximum of 50 micro-inch on cold headed surfaces. Cold heading won't cut or break the specially prepared, smooth, compressed and toughened surface of the rod.

National's cold heading specialists have many years of design and production experience. Combined with National's tremendous facilities for cold heading and secondary operations, this assures you of outstanding work and help in design and production of your parts.

Write for National's booklet, *Special Products.* To learn more about what National cold heading can do for you, send us your specifications or call in your nearest National representative.

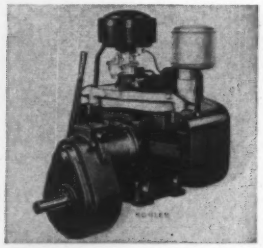
THE NATIONAL SCREW & MFG. CO. • CLEVELAND 4, OHIO

Pacific Coast: **National Screw & Mfg. Co. of Cal. • 3423 South Garfield Ave., Los Angeles 22, Cal.**

National PRODUCTS

Fasteners **Hodell Chains** **Chester Hoists**

Circle 553 on Page 19



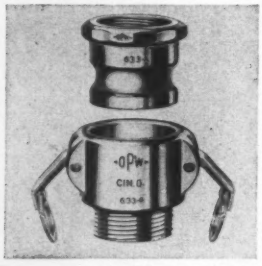
rated 24 hp at 3200 rpm engine operating speed and is designed for applications involving heavy starting loads and low power take-off speeds. Clutch reduction assembly combines a dry clutch equipped with antifriction ball bearings and a chain-drive reduction gear. Power take-off shaft is mounted on roller bearings. Engine is available in 2:1, 3.25:1, and 3.79:1 reduction ratios. Starting equipment consists of either crank starter or 6 or 12-v starter-generator. **Kohler Co.**, Kohler, Wis. K

Circle 733 on Page 19

Quick Couplers

in ½ to 3-in. sizes

Kamlok quick couplers, now available from stock, are used with hoses, pipes, and equipment wherever a quick coupler is needed. The stainless-steel units provide excellent corrosion and wear resistance,



are rated to 200 psi and 550 F. Couplers are available in ½ through 3-in. sizes in standard styles. **Jordan Industrial Sales Div., OPW Corp.**, 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 734 on Page 19

Time-Delay Relay

for intervals from
50 millisec to 4 min

Transistorized time-delay relay, for intervals from 50 millisec to 4 min, operates from external power sup-

THE

Simplest Answer

TO BEARING PROBLEMS

Bunting capability and leadership in the field of Cast Bronze Bearings and parts are well established and widely recognized. Today Bunting offers an equally comprehensive and responsible service in the field of Sintered Powdered Metal Bearings and parts.

Bunting's special knowledge and facilities make Sintered Powdered Metal products available in many applications not heretofore considered feasible. We can help you find the simplest answer to your individual problem, be it Cast Bronze or Sintered Metal.

A wide range of stock sizes of Bunting Cast Bronze and Sintered Powdered Bronze self-lubricating, plain and flange bearings, thrust bearings and bars are available from Bunting distributors everywhere in America.

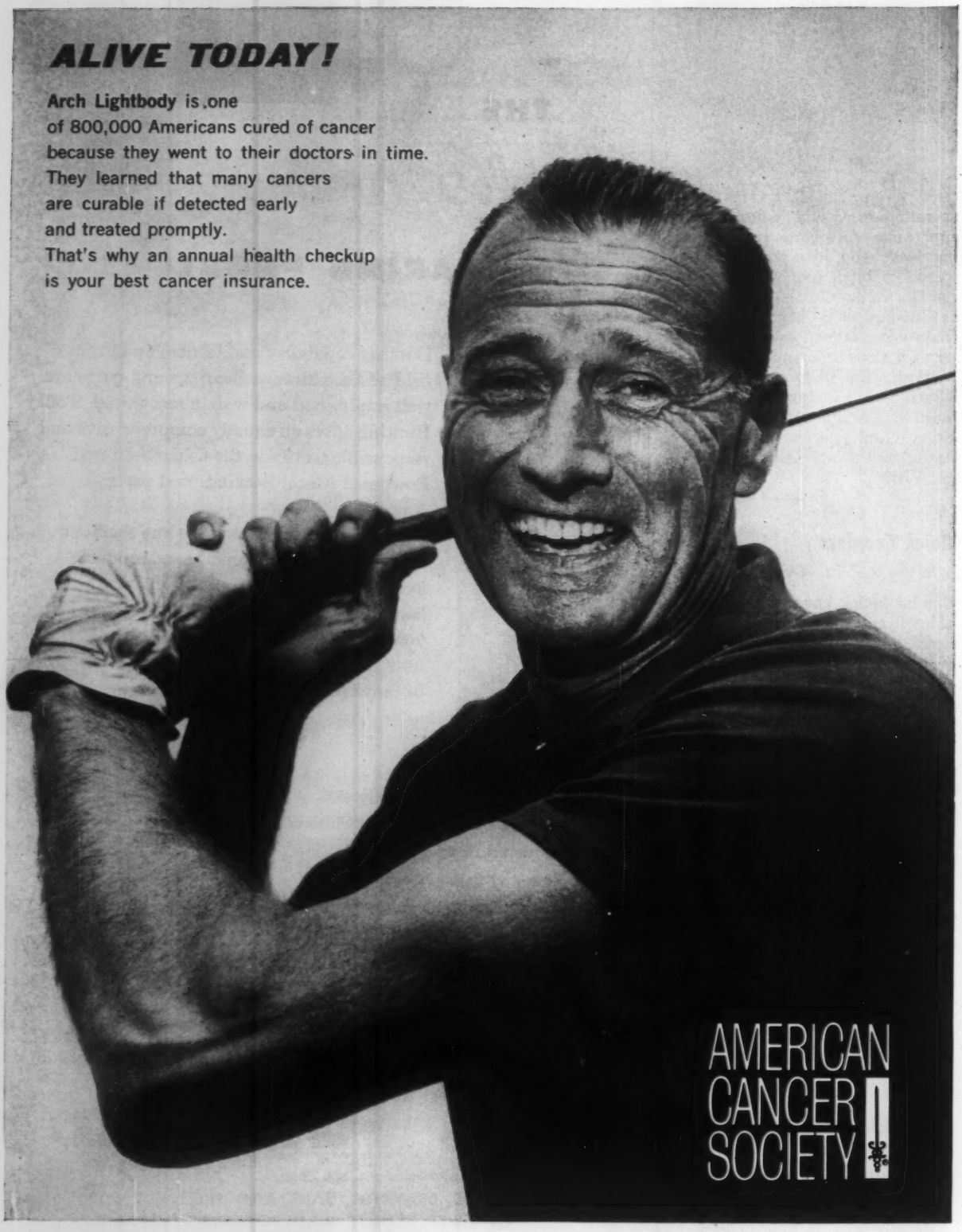
Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

Circle 554 on Page 19


ALIVE TODAY!
Arch Lightbody is one
of 800,000 Americans cured of cancer
because they went to their doctors in time.
They learned that many cancers
are curable if detected early
and treated promptly.
That's why an annual health checkup
is your best cancer insurance.
AMERICAN
CANCER
SOCIETY

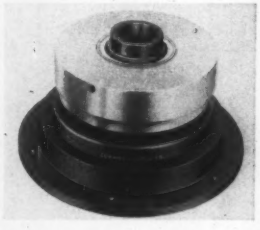
ply of 40 to 60 v dc at 0.050 ma maximum. Temperature range is −60 to 100 C. Accuracy is ±4 per cent over supply voltage variation of ±10 v dc. Repeatable accuracy is better than 1 per cent for any time cycle. Unit is for single-pole, double-throw control circuits up to 3 amp at 28 v dc or 115 v ac. **Automatic Timing & Controls Inc.**, Dept. 204, King of Prussia, Pa. E

Circle 735 on Page 19

Clutch

has nonrotating air housing and piston

New Stationaire clutch eliminates need for rotating unions, shaft drilling, and difficult shaft sealing. Air housing and piston are nonrotating with respect to rest of unit, so that unit can be mounted anywhere, even in middle of long shaft. Other features include complete interchangeability with mechanical



clutch applications, one basic drive for six different applications, adaptability to coupling mounting, and use as a double-throw clutch. **Conway Clutch Co.**, 1105 Marshall Ave., Cincinnati 25, Ohio. G

Circle 736 on Page 19

Rotary Solenoid

provides rotary output without linkages

Motoroid ratchet-drive rotary-solenoid design provides rotary output without use of linkages. Output torques can be selected from any

The new Townsend Versa-Lockbolt* is an improved, yet more economical type. Design changes have increased the grip range of the fasteners and made it feasible to use them in relatively oversized holes. They are more economical to manufacture and the savings are passed on to you.

The high tensile pre-load values and positive locking action which have made lockbolted joints absolutely vibration-proof in the past are also provided by the Versa-Lockbolts. The new flanged integral washer-collars make Versa-Lockbolts especially suitable for fastening even light gage materials.

The wider grip ranges provided by additional locking grooves in the Versa-Lockbolt permit a reduction in the sizes stocked, reducing inventory costs and increasing production line flexibility. Installation inspection is reduced, since hole sizes are less critical. These savings, plus the lower cost of the fasteners made Versa-Lockbolts a truly economical method of vibration-proof fastening.

For full information, write Townsend Company, P. O. Box 237-E, New Brighton, Pa.

*Licensed under Huck patents RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

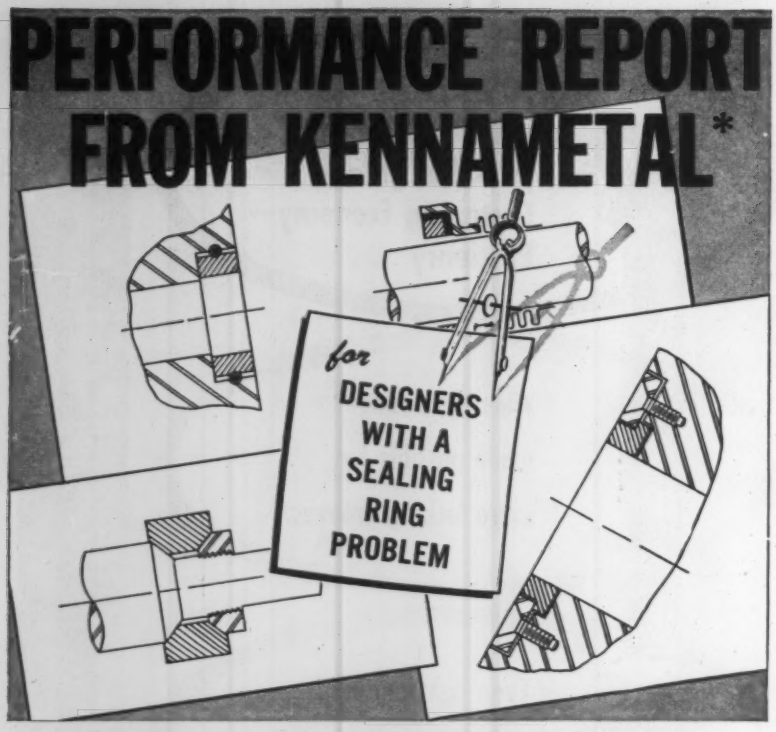
NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Cherry Rivet Division • Santa Ana, California

NEW • NEW • NEW •

PERFORMANCE REPORT FROM KENNAMETAL*



If you have any sealing ring problem that demands . . .

1. Extreme resistance to abrasion, or

2. The ability to resist elevated temperatures, or

3. Unusual resistance to severe corrosion.

KENNAMETAL has some proven answers for you.

ABRASION RESISTANCE. Kennametal tungsten carbide sealing rings installed in a deep-well rotary pump gave one to two years' service; packing type seals had failed in two to four weeks. Kennametal rings in a recirculating pump, handling water with fine grains of iron oxide, lasted 30 to 60 *days*. Packing type seals failed in 24 to 48 *hours*.

ELEVATED TEMPERATURES. A jet engine shaft seal of Kentanium,* a titanium carbide, operating without lubrication at 15,000 surface feet per minute under 0.3 to 0.6 lbs. pressure per lineal inch of circumference and 900° to 1000° F, outperformed every other material. Kentanium Rings are stress-free—do not tend to split radially, maintain original face flatness even at high temperatures, and have exceptional wear and resistance strength.

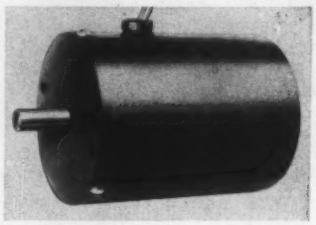
SEVERE CORROSION. Where corrosion and abrasion are present, Kennametal has seal rings of Grade K501, a platinum-bonded carbide. Used as seals to confine liquid oxygen or fuming nitric acid, sealing results are reported as "far superior to any previously used materials, with no indication of face wear."

Other desirable characteristics of Kennametal seals: high modulus of elasticity, low expansion under heat, high resistance to wear and much lower service cost. For more information, ask for "Characteristics" book, write KENNAMETAL INC., Latrobe, Pennsylvania, Dept. MD.

*Kennametal and Kentanium are the trademarks of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum. C-3070

INDUSTRY AND
KENNAMETAL
. . . Partners in Progress

part of the over-all torque curve, and angle of rotation can be varied by adjustment of stops. Models are available with left or right-hand rotations for continuous or intermittent duty. Ratchets are available



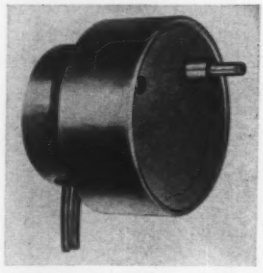
for 10 and 15-deg increments. Standard operating temperature range is −65 to 300 F. Standard operating voltage is 110 v, 60 cycle. **Leetronics Inc.**, 30 Main St., Brooklyn 1, N. Y. D

Circle 737 on Page 19

Shift Unit Motor

incorporates an internal solenoid

Model 450 shift motor incorporates an internal solenoid which assures immediate engagement of rotor and gear train when motor is energized. Same positive action is also assured when motor is de-energized, allow-



ing train to run freely. Motor, which is 2 in. in diam and 1-21/64 in. deep, is available in various speeds between 1 and 180 rpm. Output torque is rated at 9 oz-in. at 1 rpm. **Bristol Motors**, Old Saybrook, Conn. B

Circle 738 on Page 19

Motor-Alternator Sets

for units requiring 400-cycle power

Star-Kimble high-frequency motor-alternator sets with 400-cycle alternators which have no commutators, slip rings, or rotor windings supply power for machine tools,

Circle 557 on Page 19

HELPING PRODUCTION LINES ROLL FOR BETTER COST CONTROL

US®

SHAFTS

Down-time to replace a shaft on a big production line like this might idle your men, slow delivery, jack up costs. U.S. SHAFTS are your best protection against such costly overhead items.

Fine alloy steel is heat-treated by today's most advanced method. Then "millions" of steel "shots" bombard each shaft to make it up to *5 times tougher*, by actual torsion tests. Precision engineering and special ability in designing shafts for every use are based upon our 38 years of outstanding service.

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to solve your individual problems.

WRITE FOR FREE Valuable Brochure on U.S. "Custom-Engineered" Shafts

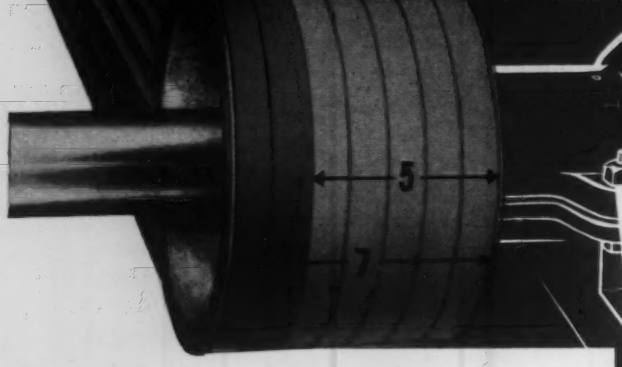
"THE WORLD TURNS ON U. S. AXLES"

THE US AXLE COMPANY, INC.

Since 1920 • Pottstown, Pennsylvania

Circle 558 on Page 19

In today's designs... 5 do the work of 7



Use fewer V-belts...get equal horsepower...save space and cost.

With 40% more horsepower, 5 Gates Super Vulco Ropes do the work of 7 standard V-belts... improve drive design. That's why—

A Super Vulco Rope Drive delivers more horsepower per dollar invested than any standard V-belt drive.

Comprehensive drive data is available to you quickly. Just call your nearby Gates distributor for a Gates V-Belt specialist. Stocks carried in industrial centers throughout the world.

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Gates® The Mark of *Specialized* Research

No other V-Belt has ALL these advantages

1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer... increases belt life...more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt... far longer belt life.

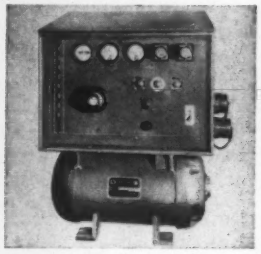
3. Tough, resilient Tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity ... easily absorb heavy shock loads... reduce number of belts required... save weight and space.

4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

TPA 331

Gates Super Vulco Rope Drives



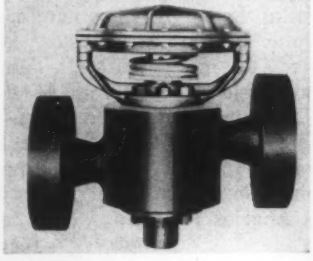
flight simulators, computers, aircraft ground-support equipment, and other applications requiring 400-cycle power. Equipment operates with little maintenance attention. Output voltage is closely maintained by control equipment integrally mounted with motor-alternator set. Units have ratings from 1.5 to 10 kw output at power factor of 80 per cent. Motor operates from ac power source, three phase, 60 cycle, 120-208 v. Output is 115-230 v single phase; also 120/208 or 220/440 three phase, regulation ±2 per cent. **Electrical Div., Safety Industries Inc.**, P. O. Box 904, New Haven, Conn. B

Circle 739 on Page 19

Air-Control Valves

for high-pressure applications

New 5000-psi air-control valves are screwed or flange-mounted and diaphragm-operated. They are for use on missile test stands or other applications requiring precise control of high-pressure air. Valves provide fast response, leakfree operation, and smooth, shockless opening and closing at maximum rated pressure. Sleeve-type construction maintains perfect alignment of valve stem and seats at all times. Complete interchangeability of precision-ground lapped stems and seat sleeves simplifies maintenance. Offered in two and three-way types, normally open or normally closed, and in ½ through 3-in. NPT sizes, valves are

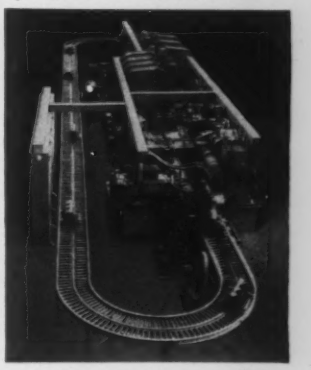


STEEL *from Wheelock, Lovejoy* BULLETIN

W-L DETROIT For the first time, HY-TEN D-2 air hardening steel now available here in rounds, squares, flats and billets. Also a fine stock of standard alloy grades, especially A-8620, as well as all HY-TEN grades. Excellent service from our new warehouse.

W-L CHICAGO Steady demand for "B" No. 3X for flame-hardened parts such as boring bars. Good stocks of HY-TEN AIS—the best carburizing alloy steel, and freest machining available today—a new W-L exclusive!

W-L CINCINNATI This 23-station Avey Line-O-Dex transfer machine, designed and built by The Avey Division of Motch & Merryweather Machinery Co., Cincinnati, Ohio, is equipped with spindles made of our HY-TEN "B" No. 2. This grade was chosen for its great tensile strength (100,000 P. S. I. in the natural condition), toughness, and fine wearing qualities.



W-L CAMBRIDGE We are now distributing FLEXANGLE, the easy-to-erect structure assembly for all types of racks, shelves, platforms, etc. It's completely universal and low in cost—can be used anywhere, by anyone, for any storage purpose.

W-L HILLSIDE Our stock of flat and square sizes in HY-TEN M Temper Oil Hardening Steel can save you time and money in your tooling program. HY-TEN "B" No. 3X pre-heat treated in rounds, squares and flats available in a wide range of sizes. Billets on hand for hammer forging in all grades of HY-TEN.

W-L CLEVELAND Excellent stock of brake die flats and squares. Also many sizes up to 16" x 18" in HY-TEN Mold Steel. Excellent deliveries.

W-L BUFFALO A wide range of rounds and hexagons in cold drawn AISI leaded and non-leaded A-4140. Also many sizes of the new "B" No. 3X-40 in rounds and hexagons.

Write our Cambridge office today for your *free* Wheelock, Lovejoy Data Sheets. They'll give you complete technical information on grades, applications, physical properties, tests, heat treating, etc.

WHEELOCK, LOVEJOY & COMPANY, INC.

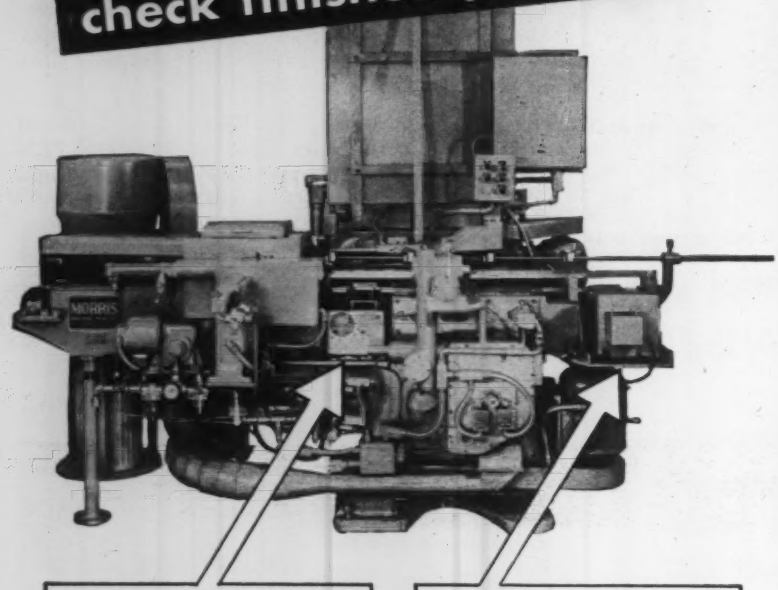
133 Sidney Street, Cambridge 39, Mass.

AMERICAN STEEL WAREHOUSE ASS'N

AGENTS: Southern Engineering Company, Charlotte, N. C.; Sanderson-Newbould, Ltd., Montreal & Toronto

Circle 560 on Page 19

Built-in SCALES pre-set machine and check finished product



PRE-SET BY EXACT WEIGHT

In MORRIS PISTON MILLING MACHINE, scale No. 1 determines amount of overweight that must be removed to balance pistons. Linkage transfers reading to depth of cut and sets machine for milling off the correct amount of excess pad.

INSPECTED BY EXACT WEIGHT

After milling, piston travels to the second scale where it is checked against predetermined weight. The SHADOGRAPH scale is adjusted to one gram, plus or minus. Should final check show over or under this amount, machine is automatically stopped.

Design Exact Weight into your machine

Precision control of automated milling machine operations is one of the many applications of Exact Weight scales in modern machine design. Exact Weight equipment controls the accuracy in food processing, packaging and textile machines, and material feeders for plastics injection molding machines.

Exact Weight scales are backed by more than 40 years of experience in industrial weighing equipment. This precision equipment, designed around given job specifications, can be incorporated into almost any machine.

If you have a problem involving control of weights or measures, call on Exact Weight's vast experience which is at your disposal. Write and give us your specific application.

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BETTER QUALITY CONTROL . . . BETTER COST CONTROL

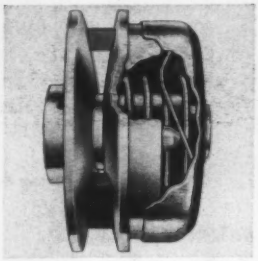
designed for actuation by any applicable pneumatic or electropneumatic pilot or cycle control device, as well as for remote manual operation. Valve diaphragm operating pressure is 35 to 40 psi air. **Sinclair-Collins Valve Co.**, 454 Morgan Ave., Akron 11, Ohio. F

Circle 740 on Page 19

Variable-Speed Pulleys

regardless of load changes

Hi-Lo FHP variable-speed pulleys provide constant speed regardless of wide variations in load. Cam automatically maintains required belt tension for a given load, pulley faces are prevented from spreading, and pitch diameter is held at desired setting. Pulleys are available in



½, ¾, and 1-hp ratings at 1750 rpm. Speed ratios are 2:1 for ½ and ¾-hp models and 2½:1 for 1-hp unit. **Lovejoy Flexible Coupling Co.**, 4932 H W. Lake St., Chicago 44, Ill. J

Circle 741 on Page 19

Mylar Zippered Tubing

withstands continuous temperatures to 400 F

Mylar Zippertubing is manufactured in laminated clear Mylar and vinyl or in a lamination of Mylar, aluminum, and vinyl with plastic or metal zipper closure and protective outer flap. Over-all thickness is either 8 or 16 mils. All types can be lined with insulating material, such as foam vinyl, polyurethane, silicone rubber, or asbestos, laminated to inner surface. Tubing is available in sizes from ⅜ to 4 in. ID, in ⅛-in. increments, in lengths from 20 ft, and in standard colors of metallic or clear. **Zippertubing Co.**, 752 S. San Pedro St., Los Angeles 14, Calif. L

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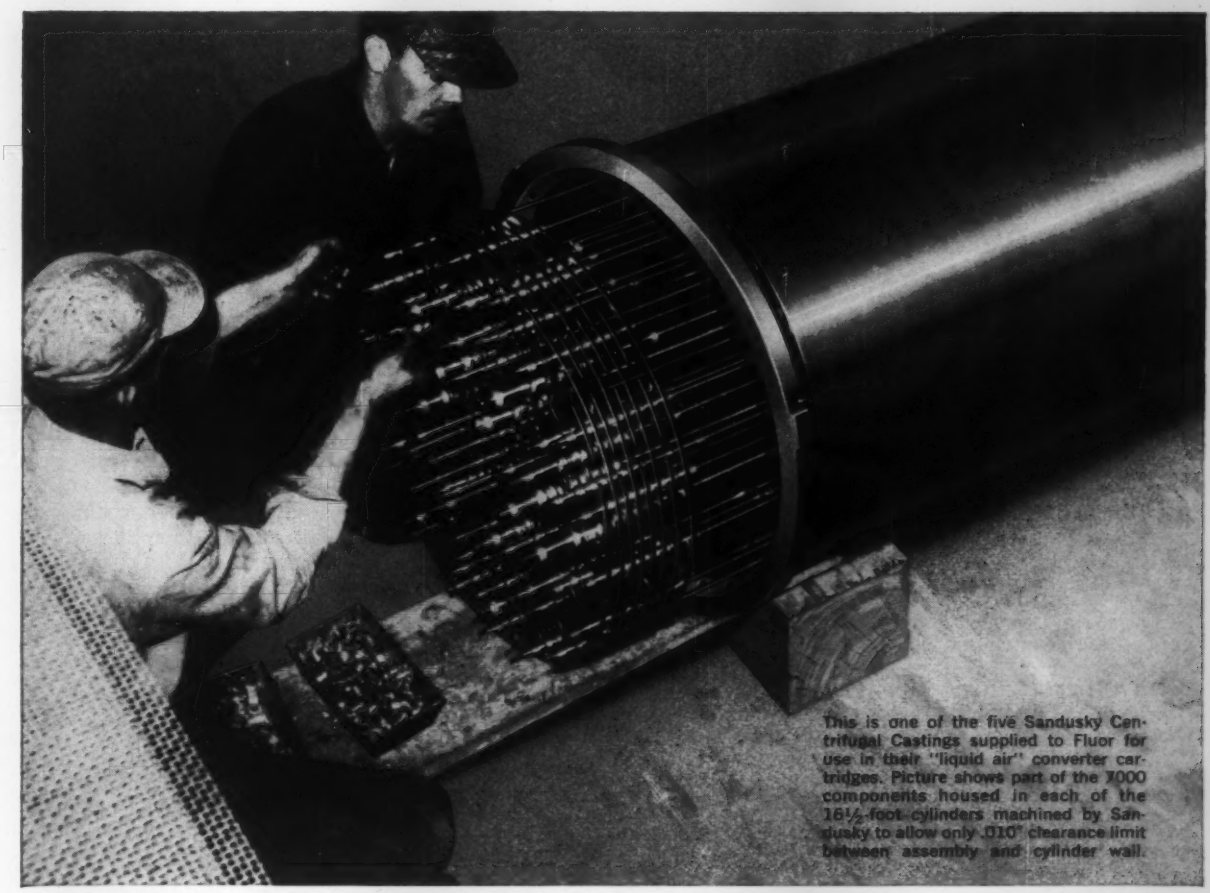
Circle 561 on Page 19



This is one of the five Sandusky Centrifugal Castings supplied to Fluor for use in their "liquid air" converter cartridges. Picture shows part of the 7000 components housed in each of the 16½-foot cylinders machined by Sandusky to allow only .010" clearance limit between assembly and cylinder wall.

SOLVED by Sandusky Centrifugal Castings:

This difficult precision-cost-delivery problem for the FLUOR PRODUCTS COMPANY.

Sandusky Quality Centrifugal Castings

Types: Rolls, Sleeves, Rings, Bearings, Bushings, Liners, Bands, Drums, Cylinders, Tubes, Shells, Retorts, Pressure Vessels, Pressure Piping

Sizes: From 7" to 54" O.D.—Lengths up to 33 feet

Materials: Stainless, Carbon and Low-Alloy Steels; full range of Copper-Base and Nickel-Base Alloys

Dimensional stability of Sandusky Centrifugal Castings enabled the Fluor Products Company to fit more than 7,000 precision parts into each of 5 identical cylinders supplied by Sandusky for use as ammonia synthesis converter cartridges.

Centrifugally cast of a modified CF8 (Type 304L) stainless steel, each cylinder was machined to finish dimensions 27¾" O.D., 26⅝" I.D., 199" long. The bore, surface finished to 35 micro inches, was held to .005" maximum out-of-roundness and .008" maximum taper.

What is more important, to meet Fluor's difficult assembly problems these large cylinders would have to be able to retain these carefully machined dimensions.

"The Fluor Products Company Engineers selected Sandusky Centrifugal Castings because of the stringent specifications, critical delivery requirements and competitive cost of this project. This was the first experience with such centrifugally cast products by the Fluor Products Company; and, the Sandusky Foundry and Machine Company people assisted in making this an extremely satisfactory and profitable project."

While you may have entirely different cylindrical design requirements, Sandusky Centrifugal Castings may well provide a similar cost-cutting answer. We would be pleased to have your inquiries.

SANDUSKY CENTRIFUGAL CASTINGS

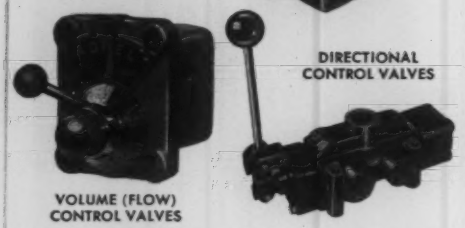
FOUNDRY & MACHINE CO.

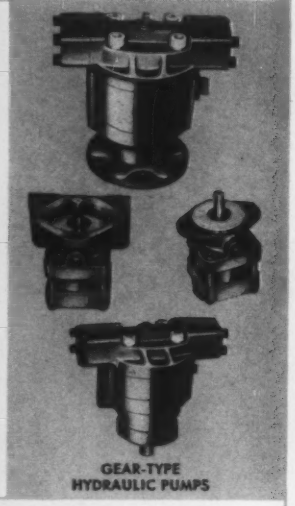
SANDUSKY, OHIO Stainless, Carbon, Low Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

Circle 562 on Page 19

ADEL *Reliability in Your Hydraulic Systems*

BETTER MACHINE CONTROL...
FOR BETTER MACHINE PERFORMANCE





New Industrial Gear Type Hydraulic Pumps with capacities from ¼ to 35 GPM at pressures to 1500 PSI and speeds to 3600 RPM.

The diagrams show but two of innumerable circuits and systems where these versatile pumps and control valves can be used to advantage.

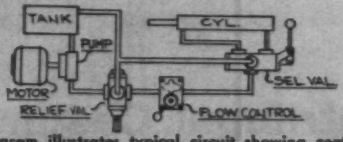


Diagram illustrates typical circuit showing control of cylinder.

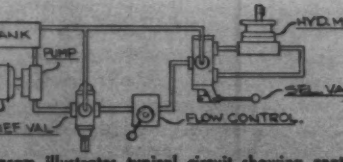


Diagram illustrates typical circuit showing control of hydraulic motor.

For metal working machines, industrial equipment, farm machinery, construction equipment, motor vehicles and marine applications... *Specify* ADEL *Precision-Engineered Hydraulics* for every mechanical operation in every industry.

Complete engineering specifications are available upon request.

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Milwaukee 17

Circle 563 on Page 19

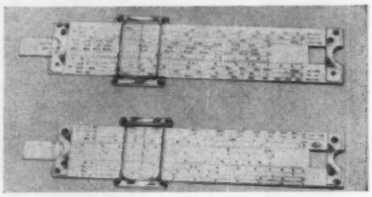
ENGINEERING DEPARTMENT

EQUIPMENT

Slide Rule

pocket-sized unit contains 23 scales

Pocket Versalog weighs only 1½ oz, measures 6¾ in. long, and contains 23 scales. Unit is constructed of laminated bamboo overlaid with white celluloid. Color coding of trigonometric scales simplifies use in conjunction with C, D, and CI scales. R1 and R2 scales permit square-root computations with greater accuracy than with A and B scales. Four log log and four reciprocal log log scales give unit excellent versatility. Log log scales cover range from 0.0005 to 0.999. Symmetrical arrangement of these two groups of scales permits facility in determining reciprocals and hyperbolic functions. **Frederick Post Co.**, P. O. Box 803, Chicago 90, Ill. J

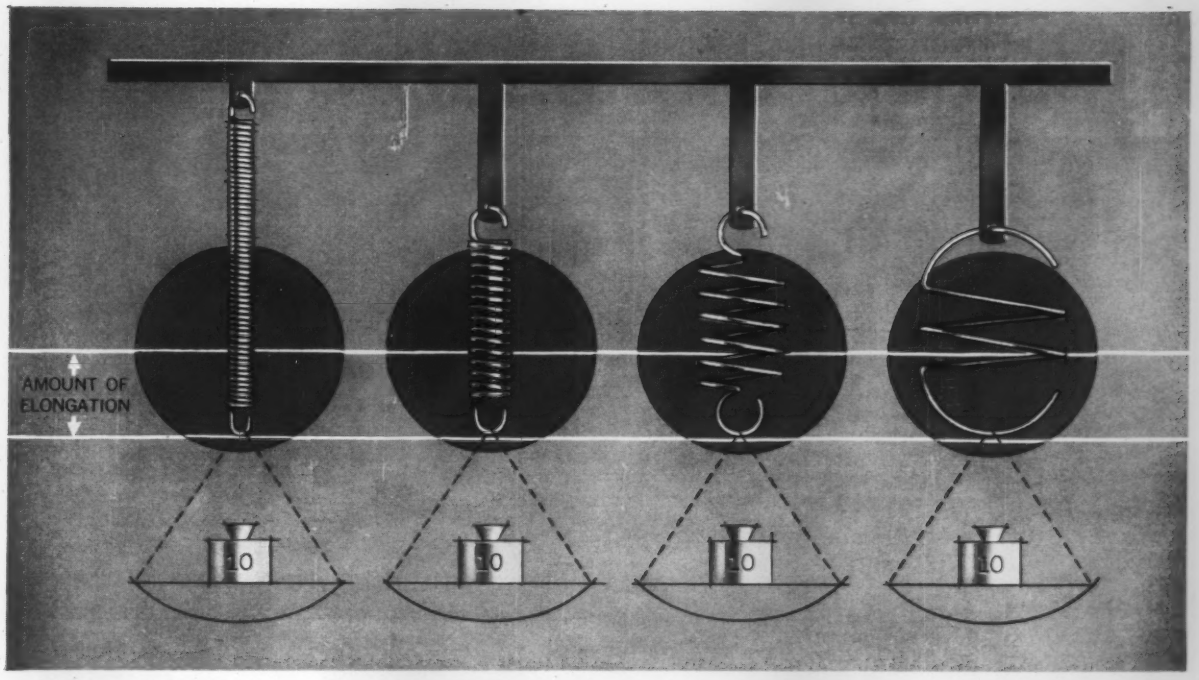


Circle 743 on Page 19

Miniature Recorder

is 25-channel, inkless unit

ER-125 miniature 25-channel inkless recorder which weighs about 4 lb is available for military and industrial applications. It resists severe shock and vibration up to 100 g; frequency response is 500 cps. Transistorized time base operating at 10 cps is furnished with standard model. Since time-base system is independent of drive-motor speed, any increase or decrease in motor speed does not affect recording accuracy. A 27-v dc (governor-controlled) motor is coupled to a gear-reduction train driving tape trans-



Spring shape and performance— or what does Spring Index mean?

One man distributes his 150 lbs. over a lean 6 ft. frame; another packs the same avoirdupois within a stocky 5 ft. 6 in. height. In a man, this might be expressed as the ratio of height to belt size. In a spring, it's a handy little ratio D/d, that of mean coil diameter to wire diameter. The illustration shows it quickly—same load—10 lbs.; same deflection—0.4 in. But in shape they range from the long thin spring at left with 75.8 coils and a spring index of 3, to the short fat spring at right with few coils and an index of 12. Application of the index ratio is particularly useful where space restrictions exist.

Our long years of specialization have developed many short cuts to spring specification to make your work easier. For general reference purposes write for pamphlet "Spring Design and Selection in Brief."

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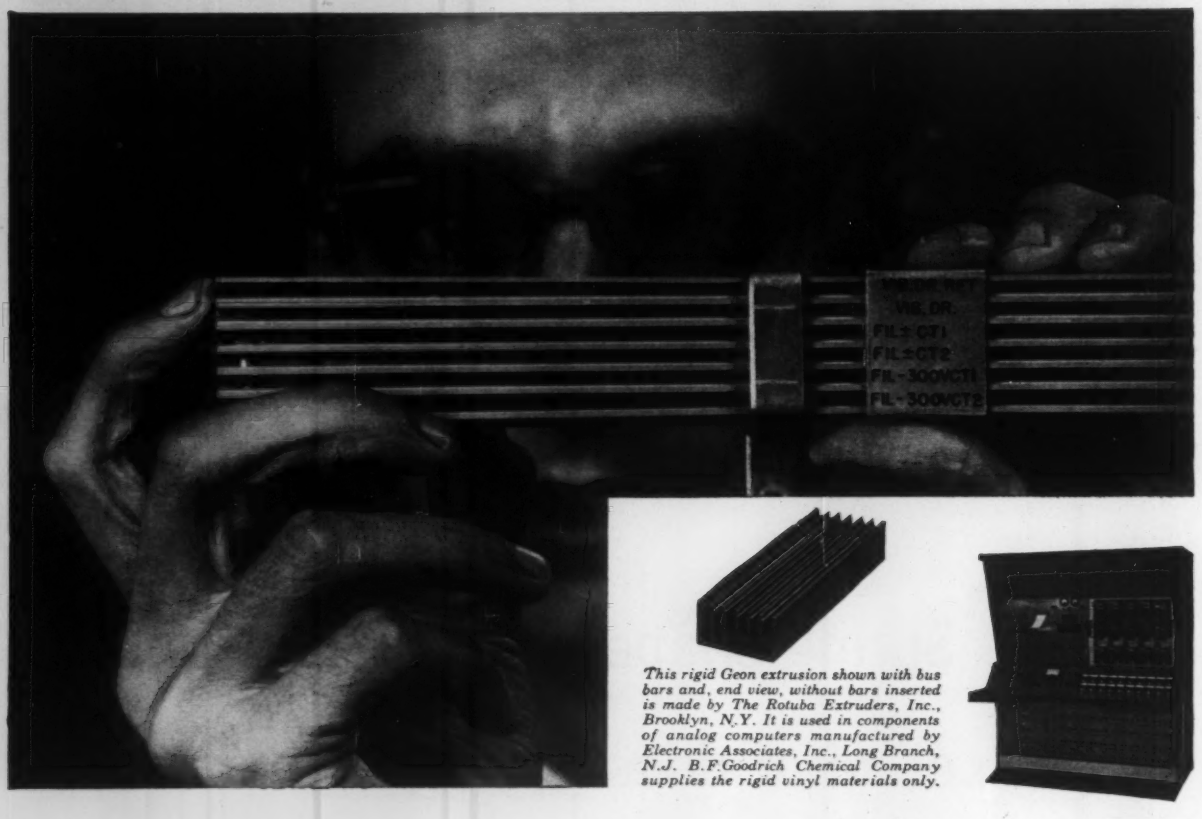
8810

Circle 564 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



This rigid Geon extrusion shown with bus bars and, end view, without bars inserted is made by The Rotuba Extruders, Inc., Brooklyn, N.Y. It is used in components of analog computers manufactured by Electronic Associates, Inc., Long Branch, N.J. B.F.Goodrich Chemical Company supplies the rigid vinyl materials only.

Extrusion of rigid Geon

. . . cuts bus bar insulation costs, saves assembly time

This extrusion of Geon rigid vinyl material saves cost, time and space for electrical assemblies. It is used to retain and insulate six strip-type bus bars of varying voltages up to 600 volts DC. They can be placed closer together because of rigid Geon's high dielectric strength and high insulation value.

Rigid Geon brings material costs down, too, for this application. It also shortens assembly time and saves weight and space.

In addition, the use of extrusions made from Geon rigid vinyl material provides good chemical and abrasion resistance. If desired, they can be colored for coding purposes. It's another example of the way Geon rigid vinyl can be the key to a new or improved product or application. For information, write Dept. **LO-7,** B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

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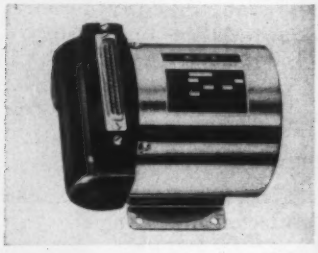
Circle 565 on Page 19



port system at nominal speed of 5 ips. Recording tape is either metalized Mylar 0.0015 in. thick or chemically treated Alfax paper. Each of 25 writing elements thermally transcribes various transducer functions directly on recording medium. **Santa Barbara Instrumentation Corp.**, 5481 Santa Monica Blvd., Los Angeles 29, Calif. L

Circle 744 on Page 19

Template

for dimensioning and tolerancing

No. 52 dimensioning and tolerancing drafting template contains cutouts for symbols recommended by MIL-STD-8A for flatness, straightness, angularity, parallelism, and concentricity. Also included are standard sizes of rectangles and circles for use with symbols, complete alphabet and numbers in 1/4-in. size, plus arrowheads for dimen-

sional lines and standard finishing symbols. Made of 0.030-in. matte-finish plastic, template measures 6 1/4 by 2 1/4 in. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif. L

Circle 745 on Page 19

Strain-Gage Cement

for use in temperatures from −300 to 700 F

No. 200 strain-gage cement bonds Bakelite and other strain gages for use in temperatures from −300 to 700 F. Material has short cure cycle and low bonding pressure of 10-12 psi. It can also be used to bond high-temperature foil gages and

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do so many outstanding
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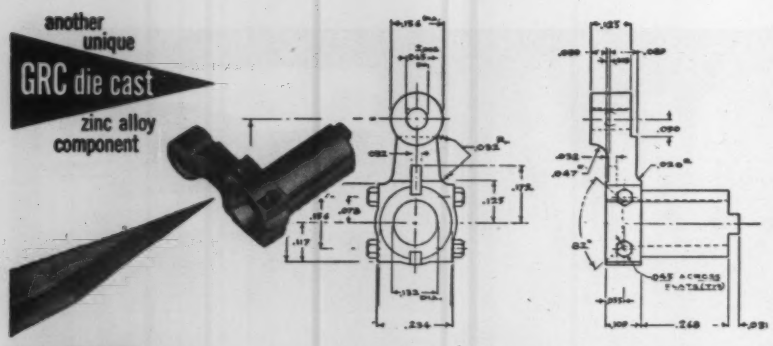
Producers of Quality Wire Products for Home, Farm and Industry

Circle 566 on Page 19

another unique GRC die cast zinc alloy component



GRC die casting helps Lionel achieve tiny part authenticity

This intricate toy crank was die cast in zinc alloy by GRC in a single automatic operation. Cost? Little more than $5.00 per thousand in lots of 500,000. Result? Produced quicker and more economically than Lionel could themselves. Less than half an inch overall, it is typical of the many small (maximum is 1¾" ½ oz., no minimum) parts problems solved by GRC's unique techniques. Gries' specialized machines deliver parts ready for use—uniform, accurate, clean—no trimming, no assembly, no scrap loss.

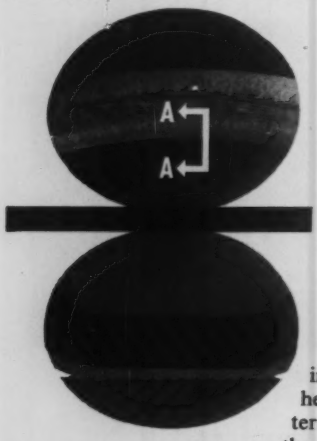
If you have a small parts problem, write, wire or phone for GRC's die casting bulletin or send prints for quotation.

World's Foremost Producer of Small Die Castings

GRIES

GRIES REPRODUCER CORP.
32 Second St., New Rochelle, N. Y., NEw Rochelle 3-8600

Circle 567 on Page 19



TOP: Tool marks visible in TEFLON coating, magnified 12X.

BOTTOM: Section A-A TEFLON . . . conforms to irregularities in machined surface.

PERFECT SEAL . . . Teflon* coating mates United's metallic O-ring to surface!

Teflon, permanently bonded to a United metallic O-ring, conforms to normal tool marks which it contacts in a machined seat. This remarkable, non-porous, pliable coating compresses into these irregularities to help form a perfect seal. Spring steel characteristics of the O-ring metal are retained, and the surface conformability of a rubber-like compound is added. Finish is completely non-corrosive and resistant to chemical action. Tests with gases and liquids, at high and low pressures, prove absolute sealing action. United also makes hollow tube; pressure-filled; and patented† self-energized metallic O-rings; and wire and brazing O-rings to practically any required dimensions. Write for information (on your letterhead please).

*TEFLON IS THE REGISTERED TRADEMARK FOR DUPONT TETRAFLUOROETHYLENE RESINS. † PATENTS 2,809,269; 2,837,360

UNITED METALLIC "O" RING CORP.
Dayton, Ohio • Box 1035
Division of United Aircraft Products, Inc.

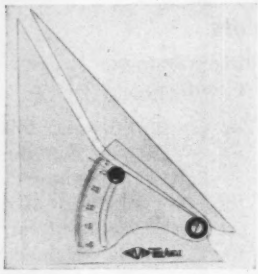
temperature transducers to test specimens. **Mithra Engineering Co.**, P. O. Box 1294, Beverly Hills, Calif. L

Circle 746 on Page 19

Fluorescent Triangles

combine functions of protractor and triangle

New fluorescent adjustable triangles combine the functions of a protractor and triangle. Right triangle permits drawing of accurate angles from zero to 90 deg direct from baseline. Protractor element has two rows of die-sunk graduations. Outer row indicates angles from 0 to 45 deg from base, and inner row indicates angles from 45 to 90 deg from shorter base. Angles can be set to graduations of ½ deg



with accuracy. Fulcrum point has aluminum screw post to insure lasting, firm movement. Material is highly ductile, rigid, and shatter-resistant, with thickness of 0.100 in. Triangles will not darken, discolor, decompose, or warp with repeated use. **Alvin & Co. Inc.**, Palisado Ave., Windsor, Conn. B

Circle 747 on Page 19

Accelerator

has output ratio to 60 v in ±1 to ±50-g range

Model 7-34 differential-transformer accelerator has output ratio to 60 v in a range from ±1 to ±50 g. Temperature compensation is within 0.1 per cent of critical during damping, without use of heaters. Compact in size, unit combines high voltage output efficiency, infinite resolution, precision axes alignment, and low threshold sensitivity. Output at full deflection is 0.5 v per v excitation, and at zero acceleration, null is less than 0.5 per cent of full scale. Unit is available for standard electrical input, with any ac voltages

Waldes Truarc Prong-Lock Ring Eliminates Springs, Washers, Takes Up End-Play

WALDES TRUARC
SERIES 5139 RETAINING RING*

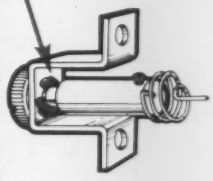
application: external for shafts
range: 3/32" through 7/16"

*U. S. Pat. No. 2,755,698

After radial application, the Waldes Truarc Prong-Lock retaining ring locks and holds securely in its groove by means of two prongs. Because of its resistance to radial displacement, the ring may be used as a shoulder for rotating parts. Thrust-load capacity ranges from 80 to 700 lbs. for sizes from 3/32" to 7/16". Bowed construction provides end-play take-up, often eliminating springs, washers and accessory devices.

Rings replace cotter pins, spring-washers; save $68.00/M

Mason-Neilan Division of Worthington Corp., Norwood, Mass., uses two Waldes Truarc Series 5139 Prong-Lock rings on its pressure controller to secure pivots through which a right angle micrometer adjustment screw passes. Each ring replaces hairpin-type cotter pin and bowed washer. . . provides necessary tension to prevent adjustment screw from shifting. Manufacturing costs were reduced by $68 per 1,000 units.



Ring replaces locknut, eases control calibration

On a differential pressure control mechanism, Taylor Instrument Companies, Rochester, N. Y., replaced a locknut and eliminated a costly threading operation with a series 5139 Prong-Lock ring. Also eliminated is the loosening and tightening of the locknut before and after each calibration setting. Spring action of the ring securely holds the calibration setting.

Whatever you make, there's a Waldes Truarc Ring designed to save you material, machining and labor costs, and to improve the functioning of your product.

In Truarc, you get:

Statistically Controlled Quality from engineering and raw materials to the finished product. Every step in manufacture watched and checked in Waldes' own modern plant.

Complete Selection: 36 functionally different types. As many as 97 standard sizes within a ring type. 5 metal specifications and 14 different finishes. All types available quickly from leading OEM distributors in 90 stocking points throughout the U. S. and Canada.

Field Engineering Service: More than 30 engineering-minded factory representatives and 700 field men are at your call.

Design and Engineering Service not only helps you select the proper type of ring for your purpose, but also helps you use it most efficiently. Send us your blueprints today . . . let our Truarc engineers help you solve design, assembly and production problems . . . without obligation.

e 1

WALDES
TRUARC®
RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, N. Y.

Waldes Kohinoor, Inc., Long Island City 1, N. Y.

Please send me additional information and engineering data for the Truarc Prong-Lock Ring, Series 5139.

Name_____

Title_____

Company_____

Business Address_____

City_____ Zone____ State_____

MD-110

Consult the Yellow Pages of your Telephone Directory for name of Local Truarc Factory Representative and Authorized Distributor. Look under "Retaining Rings" or "Rings, Retaining."

©1958 Waldes Kohinoor, Inc.

Circle 569 on Page 19

A Review of the Phosphate Coatings

Specified for the Protection of Metal Surfaces

By HUGH GEHMAN, Assistant Manager, Product Development Dept., Amchem Products, Inc.

Phosphate coatings are protective inorganic finishes that actually change the chemical nature of metal surfaces. The metal reacts with the applied phosphate solution to form a nonmetallic, crystalline coating which serves to:

- **Improve paint adhesion**
- **Provide protection against corrosion**
- **Increase lubricity of friction surfaces**
- **Facilitate mechanical deformation of metals**
- **Decorate—in many instances**

Satisfactory protection of steel, zinc and aluminum surfaces against corrosion, paint peeling and blistering, and hard wear requires precision methods of chemical conversion coating.

Types of Conversion Coatings

There are seven classes of chemical conversion coatings commonly specified and used throughout industry today. They are as follows:

Zinc-iron phosphate (ACP Granodine®). This is the heaviest type of coating (gray in color) used for prepaint treatments on steel, iron and zinc surfaces. The process requires five or six operations: cleaning; rinsing; rust removal, if necessary; coating; rinsing; and a second rinse. Coating weight ranges from 100 to 600 mg per sq. ft.

Medium or large volume production of automobile bodies, appliances, projectiles and cabinets can be handled effectively.

The coating solution improves paint adhesion by forming a crystalline deposit over the metal surface. This deposit is rough, as revealed microscopically, and so offers an ideal gripping surface for paint particles.

Manganese-iron phosphate (ACP Thermoil-Granodine®). This is a heavy black coating used on friction surfaces to prevent galling, scoring and seizing of parts. Typical metal parts treated are pistons, piston rings, gears, cylinder liners, camshafts, tappets and various small arms components.

Iron phosphate (ACP Duridine®). This is a comparatively new process that places a light coating on surfaces for improved paint adhesion. Since cleaning and coating occur in the same bath, it has only three to five stages.

The iron phosphate treatment is a spray process suited for medium to large volume, large or small work. Precleaning is normally unnecessary, an economy factor in its favor.

Products protected by this process are steel or iron fabricated units, such as cabinets, washing machines and refrigerators. Weight of coating is 50 to 100 mg per sq. ft.

Zinc phosphate (ACP Lithoform®). This is a crystalline coating produced on galvanized iron and other zinc surfaces—also cadmium—for improving paint adhesion. The purpose of the coating is to provide a paint-gripping surface and to prevent the reaction between acidic components of the paint and the zinc metal, with the formation of soaps and loss of paint adhesion.

This coating is applied in weights of 75 to 500 mg per sq. ft. There are no limitations on volume or production or on size of products treated. Zinc phosphate coating is used on zinc alloy die castings, zinc or cadmium plated sheet or components, hot dip galvanized stock, and Galvanneal.

Amorphous phosphate (ACP Alodine®). This is a relatively new protective coating for aluminum and aluminum alloys. It may be used in place of anodic deposition for improved paint adhesion and corrosion resistance.

This coating is practical for production in any volume. Coating weight is 100 to 600 mg per sq. ft. Products treated include helmets, belt buckles, aircraft and aircraft parts, bazookas and rocket motors, roofing and siding. Particularly good when aluminum is painted prior to forming.

Zinc-iron phosphate for oil absorption (ACP Permadine®). This is a relatively heavy coating adapted to the retention of rust-inhibiting drying or nondrying oils and waxes on ferrous metal surfaces. The coating is applied to a weight of 1000 to 4000 mg per sq. ft.

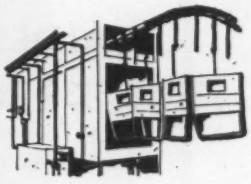
The process is satisfactory for large or small work in any volume—nuts, bolts, hardware, guns, tools, etc.

Zinc-iron phosphate for metal forming (ACP Granodraw®). This is a specialized coating used in conjunction with a suitable lubricant to facilitate the cold mechanical deformation of steel. The coating acts as an anchor for the lubricant throughout drawing, extrusion, and cold forming operations.

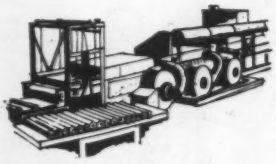
It is a successful treatment for products such as blanks and shells for cold forming, heavy stampings, impact extruded shapes, drawn wire and tube.

For more complete information about any one or all of these chemical conversion coatings, contact an ACP sales representative or write us at Ambler, Pa.

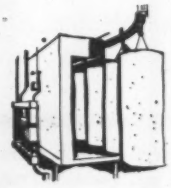
Typical Installations of Phosphate Coating Systems



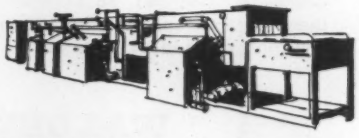
Customer: Truck manufacturer
Problem: Preparing cab parts for painting
Cycle: Phosphate wash; phosphate wash; rinse; chromic acid rinse; dry



Customer: Aluminum screen manufacturer
Problem: Final finish of aluminum shade screen
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry



Customer: Water heater manufacturer
Problem: Preparation of water heater shells for synthetic enameling
Cycle: Phosphate wash; rinse; chromic acid rinse; dry



Customer: Hardware manufacturer
Problem: Preparing hardware parts for painting
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry

Amchem Products, Inc.
Ambler 44, Pa.
Formerly
AMERICAN CHEMICAL PAINT COMPANY
CHEMICALS ACP PROCESSES
DETROIT, MICH. • ST. JOSEPH, MO.
NILES, CALIF. • WINDSOR, ONT.
New Chemical Horizons for Industry and Agriculture

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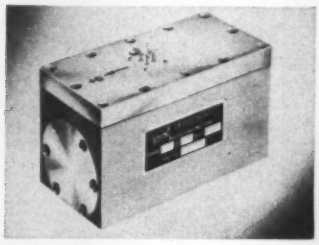

and frequencies at 400 cps. **Edcliff Instruments**, P.O. Box 565, Monrovia, Calif. L

Circle 748 on Page 19

Self-Sticking Tapes

for printed-circuit master layouts

Self-sticking terminal circles, fillets, and connector strips for printed-circuit master layouts have a new transparent adhesive, designated B-150, which eliminates smudge marks on master layouts caused by adhesive residue of black tape. Circles, fillets, and special shapes are mounted on dispenser cards to maintain ±0.005 in. tolerance. Connector strips in 18 and 60-yd rolls are also available in the new tape. **W. H. Brady Co.**, 727 W. Glendale Ave., Milwaukee 9, Wis. K

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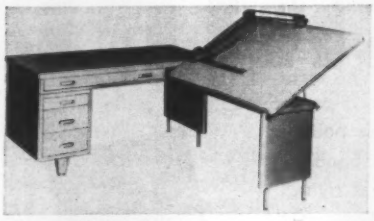
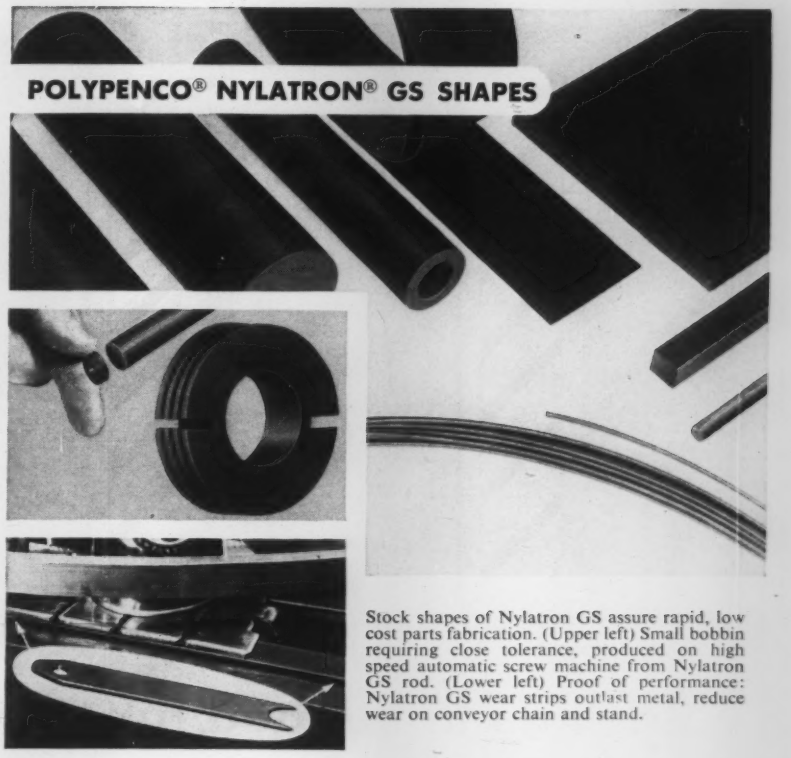
Desk-Drawing Board

L-shaped unit has 27½ sq ft of surface



New all-steel, L-shaped unit is a desk and drawing board combination which provides 27½ sq ft of surface. Drawing board drops to a completely horizontal position, permitting use of full working surface. Either left or right-hand models are furnished in two-tone combinations of 14 basic colors. Top of pedestal-type desk is 60 x 30 in., and drawing surface measures 60 x 36 in. Drawing board can be elevated to 85-deg angle. **Standard Pressed Steel Co.**, Jenkintown, Pa. C

Circle 750 on Page 19



Stock shapes of Nylatron GS assure rapid, low cost parts fabrication. (Upper left) Small bobbin requiring close tolerance, produced on high speed automatic screw machine from Nylatron GS rod. (Lower left) Proof of performance: Nylatron GS wear strips outlast metal, reduce wear on conveyor chain and stand.

Special properties of NYLATRON GS nylon provide parts with unusual wear life

One of the newest industrial plastics available to designers is POLYPENCO Nylatron GS nylon —supplied in standard stock shapes. Nylatron GS is a molybdenum disulphide filled nylon composition*. This special formulation results in a product with proven property advantages:

Greater Rigidity
Parts have higher modulus of elasticity, show less deformation under load than nylon 101.

High Heat Distortion Temperature
Nylatron GS parts have higher heat distortion temperatures than standard nylon 101.

Low Thermal Expansion
Coefficient of thermal expansion is approximately 60% of nylon 101.

Low Surface Friction
When wear parts must run dry, Nylatron GS parts operate without lubrication.

High Wear and Abrasion Resistance
Part surfaces resist abrasion and demonstrate long wear in contact with metals.

The chemical and electrical properties are similar to nylon 101.

Nylatron GS is available in all standard shapes and sizes including rod, strip, tubing, tubular bar and plate. It is also available in powders for molding. Write today for performance and application data on POLYPENCO Nylatron GS nylon.

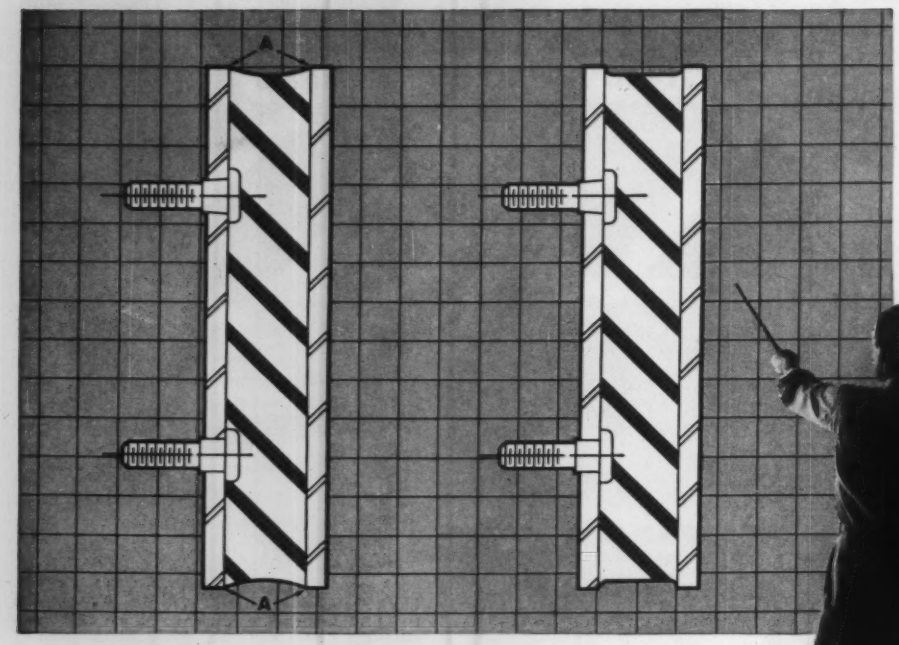
**Patents applied for*

THE POLYMER CORPORATION OF PENNA.
Reading, Pa.
Export: Polypenco, Inc., Reading, Pa., U.S.A.

POLYPENCO®

POLYPENCO Nylon, POLYPENCO Teflon†, NYLAFLOW and NYLATRON® GS †DU PONT TRADEMARK

Circle 571 on Page 19



Savings in molded rubber parts begin with improved design

thru **ORCO**

CUSTOMEERING

Similar designs? Almost, but not quite. In the design at left, "A" is a stress point. The shrinkage of the rubber can cause concentrated strain at the edges of the bonded area. Ohio Rubber engineers would probably recommend the design shown at right.

Attention to important details like this is typical of ORCO's "customeering" of parts made from rubber, synthetic rubber, silicone rubber, polyurethane, and flexible vinyl, whether they be molded, extruded, or bonded to metal.

From components weighing less than a gram to parts of over 73 lbs., whatever the shape involved, ORCO's integrated research, design, electronically controlled compound mixing, and production facilities, assure component uniformity and quality to meet the most exacting requirements. Check with ORCO engineers on your next rubber or vinyl component problem. Your inquiry will receive prompt attention.

Send for free booklet "Component CUSTOMEERING rubber and vinyl parts".

THE OHIO RUBBER COMPANY

A Division of The Eagle-Picher Company
Willoughby, Ohio

Circle 572 on Page 19

Stress Relief

"This is our small but efficient drafting department."

EFFICIENT drafting, the subject of this cartoon which appeared in the March 20, 1958 issue of MACHINE DESIGN, inspired one of our readers to tell us—by means of a letter and another cartoon—of his own, similar situation:

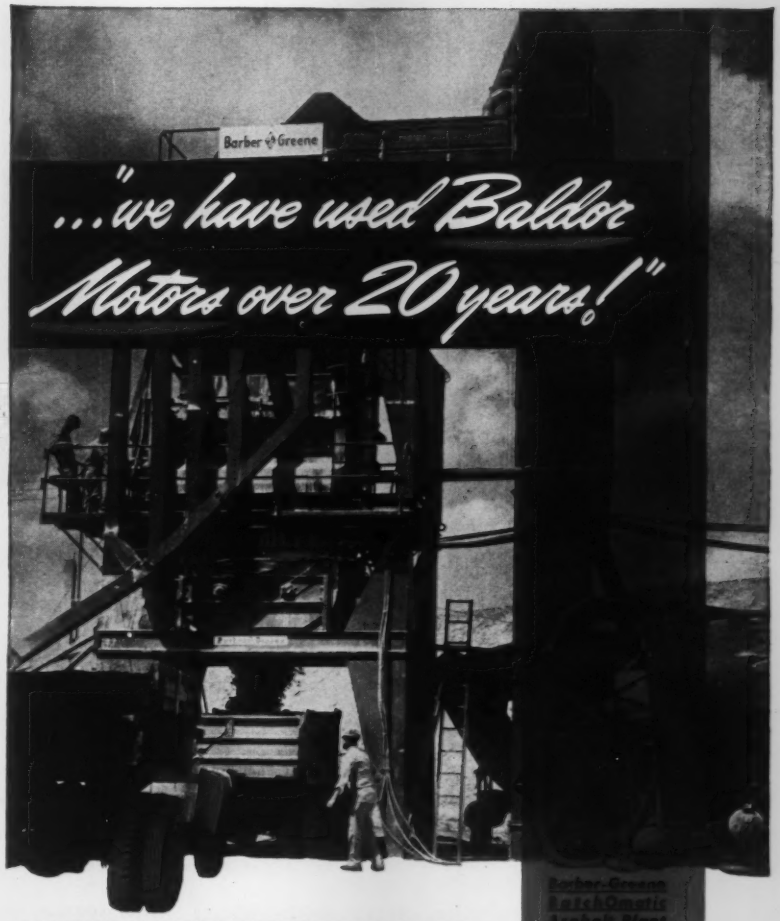
Dear Editor:

I enjoyed Mr. Scheffy's cartoon very much, as it seemed to closely portray my own situation. I intended to write and tell you sooner, but you see I am the guy in the middle of the cartoon, so I have been busy.

I thought you would be interested to know what has happened to the people in the picture.

The owner—that's the one in the black coat—retired two months ago and left his son to run the business. Well, the son is fresh out of college with ideas about stepping up production.

Pete—that's the guy with the scissors—was a junior engineer who wanted to make a lot of money, but the boss couldn't help him because Pete has only been with the firm five years so he wasn't completely proficient in his duties. He recently transferred over into the building maintenance department. There he is called an engineer—without the "junior." He got a large increase in salary and the last time



BARBER-GREENE Depends on Baldor Streamcooled Motors to Power Its Asphalt Batch Plants & Belt Conveyors!

Despite the most torturous use, plus the constant hazard of dust and dirt, Baldor Streamcooled Motors keep famous Barber-Greene equipment operating at top efficiency, day after day.

This kind of superior performance has earned Baldor an enviable reputation among many outstanding heavy equipment manufacturers.

If you have a power problem that demands the utmost in motor performance, perhaps Baldor can help you, too!

Find out why you get *more* with Baldor —write for FREE color catalog!

BALDOR ELECTRIC COMPANY

4353 Duncan Ave. **St. Louis 10, Missouri**

Over 400 Authorized Sales & Service Distributors in U. S. A.

District Offices: Atlanta • Chicago • Cincinnati • Cleveland • Dallas • Des Moines • Detroit • Indianapolis Litchfield, Conn. • Los Angeles • Milwaukee • Minneapolis • New Orleans • New York • N. Kansas City, Mo. Oakland • Philadelphia • Portland, Ore.

Circle 573 on Page 19

new

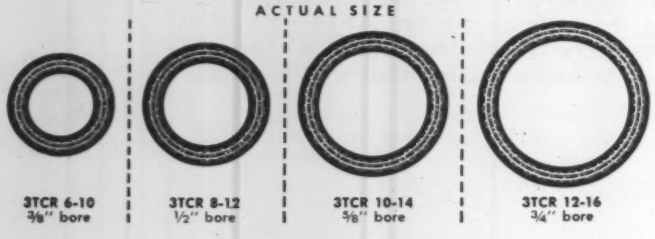
small bearings for big jobs

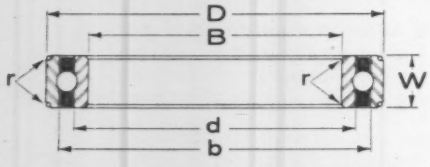
Thin-section **midget** T series precision ball bearings were designed primarily for instrument application, and to bring new, high standards of performance to their size range. Actual sales experience has shown a much wider range of application for these versatile bearings than heretofore anticipated.

These bearings feature: (1) light, one-piece retainer with true maximum ball complement — good for low torque values. (2) savings from 46% to 90% on space requirements, compared with conventional inch-series ball bearings of equivalent bore size. (3) no loading slot or other design compromise which might limit thrust capacity. (4) high ratio of load capacity to bearing volume. (5) rings and balls of stainless steel; retainer of pressure-molded fibre-reinforced phenolic. Made in precision and ultra-precision grades.

For complete information, get our catalog 59 . . . Write today.

ACTUAL SIZE





*B bore ± .0002	*D o.d. + .0000 − .0004	W width + .0000 − .0050	†r radius	b outer land ± .001	d inner land ± .001	Balls no.	Balls size	‡L lbs.	§S lbs.
.3750	.6250	.15625	.010	.542	.457	16	1/16	77	110
.5000	.7500	.15625	.010	.672	.587	21	1/16	89	144
.6250	.8750	.15625	.010	.797	.712	24	1/16	94	165
.7500	1.0000	.15625	.010	.922	.8375	30	1/16	101	206

Dimensions are in inches. *Tolerances shown are for Precision Grade. Write for Ultra Precision Grade tolerances. †r is maximum fillet radius on shaft or housing that bearing will clear. ‡Radial load capacity at 500 rpm and 2500 hours average life. §Static non-Brinell load capacity.

split ballbearing
A DIVISION OF MPB, INC.
306 HIGHWAY FOUR, LEBANON, NEW HAMPSHIRE

I saw him he was learning how to sweep and some days he has to watch the fire burn in the furnace. So far they haven't replaced him.

Bill—that's the one with his hand in his pocket—was a real intelligent one (you could see that by the expression on his face). Well, his right arm got tired and there was no one to tell him to turn around and use his left arm, so he turned in an idea that they get a machine to turn the paper. The award board decided that would eliminate Bill's wages so they gave him a sum equal to two years' pay and laid him off. Bill used his head, though, and put the money into company stock, so now he is a vice president with a private office.

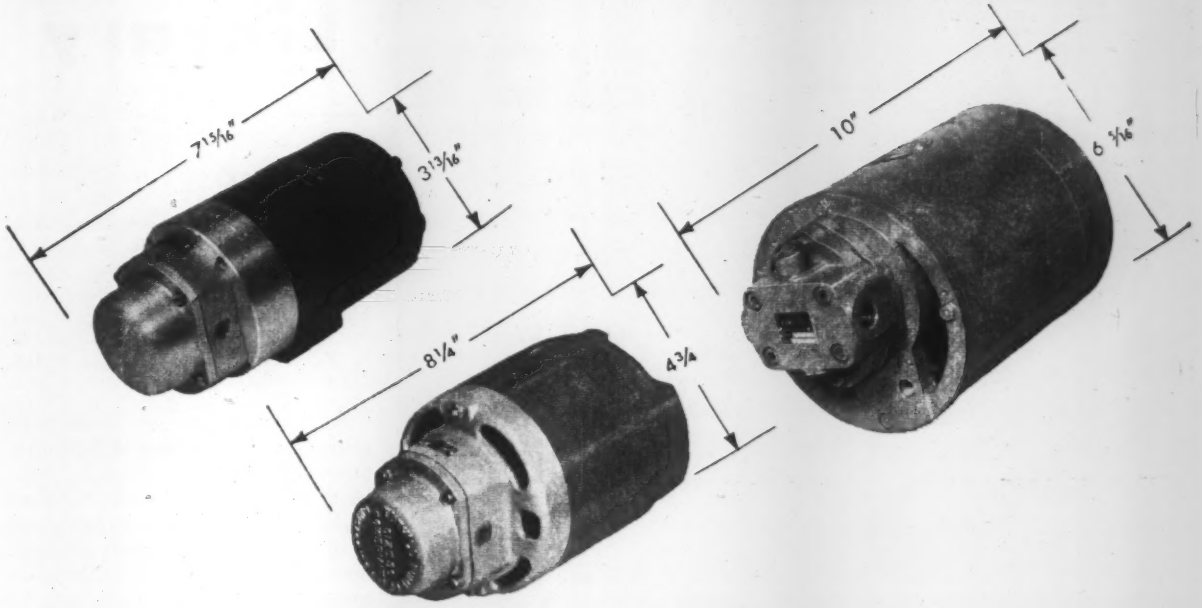
They haven't cleared the budget yet to buy the machine to replace Bill, but it may come through next fiscal year if taxes are lower then.

Mike—that's me, the guy with the pencil. I'm an engineer too, and I don't make very much, and it seems I work very hard. I haven't had time to look for another type of work because I've been too busy. But then, I enjoy creating things—it's so satisfying. Why, only the other day the plant manager told me that the last machine I designed had earned the company over $3 million so next month they are raising my wages to $350 per month. That's what makes me enjoy my work so, just to know that my work is appreciated.

I've made a few changes in our drafting department which make my work easier. I thought you might be interested to see how I am getting along these days, so I am enclosing a sketch of myself at work.

—Mike Rometer

Cut Product Costs with POWERMITE



custom engineered pump and motor combinations

More and more manufacturers are learning the economy of incorporating Tuthill's exclusive Powermite Pump and Motor Combinations in their products. These custom engineered units incorporate a specially designed electric motor into a rotary gear pump . . . to produce a combination unit which takes up no more space and weighs no more, than a conventional electric motor.

The Powermite's compactness solves tough design problems. Its small size and low weight make it easier to install . . . boost production line productivity. The elimination of bases, couplings and other parts result in substantial economies. Its lower weight reduces shipping costs. And all Powermites provide the long trouble-free life which industry has learned to expect from Tuthill.

Wide range of combinations

A wide range of pump and motor combinations can be provided to meet individual requirements in hydraulics, lubrication, circulating, coolant, and other pump services. Three typical examples are shown above.

The compact unit to the left, developed for use on a small mobile hoist, combines an internal gear pump rated for 30 cu. in./min. at 500 psi, with a 1/8 hp motor. The center unit, developed for a low pressure hydraulic application combines an internal gear pump with a capacity of 16 gph at 250 psi with a 1/12 hp motor. The unit at right combines a high pressure hydraulic spur gear pump, for rated conditions of 1 gph at 1,000 psi with a 3/4 hp motor.

Custom engineered for your application

Each Powermite model is custom engineered for a specific OEM application and is designed to permit substantial economies for high volume production. A few Powermite models are available from stock—for example, the 350 psi, 16 gph model shown at center above. For small quantity applications Tuthill Close Coupled Pump and Motor Combinations can provide similar savings.

Manufacturers interested in learning more about the advantages of incorporating Powermite combinations into their products are invited to forward detailed specifications. Or, if preferred, a Tuthill Field Engineer will call

TUTHILL PUMP COMPANY
953 East 95th Street
Chicago 19, Illinois

Gentlemen:

☐ Please have representative call to discuss Powermite applications in my product.

☐ Please send catalog describing complete Tuthill line.

NAME _____ TITLE _____

COMPANY _____

STREET _____

CITY _____ STATE _____

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GPM; for Pressures to 1500 PSI; speeds to 3600 RPM.

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY

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Recent Books

Aircraft and Missile Propulsion, Volume II. *By M. J. Zucrow, professor of gas turbine and jet propulsion, Purdue University; 636 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN; *$13.00 per copy postpaid.*

A presentation of underlying principles of propulsion of the turboprop, turbojet, ramjet, liquid-propellant rocket, and solid-propellant rocket. This volume is concerned with analysis of the cycles and performance characteristics of these engines.

Dynamical Analogies. *By Harry F. Olson; 278 pages, 6 by 9 in., clothbound; published by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from* MACHINE DESIGN; *$6.75 per copy postpaid.*

This book discusses analogies which exist between electrical, mechanical, acoustical and magnetic systems. Simple arrangements of single element systems and complex arrangements of multi-element systems are covered.

Chapters include classic analogies as well as magnetic and mobility analogies, noise, distortion, and feedback.

Thorium Production Technology. *By F. L. Cuthbert; 303 pages, 6 by 9 in., clothbound; published by Addison-Wesley Publishing Co. Inc., Reading, Mass.; available from* MACHINE DESIGN; *$6.50 per copy postpaid.*

This book contains information on thorium; its physical and mechanical properties, extraction, purification, fabrication, compounds, and testing procedures.

Epoxy Resins. *By Irving Skeist; 293 pages, 5 by 7½ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $5.50 per copy.*

Circle 576 on Page 19

Circle 577 on Page 19→

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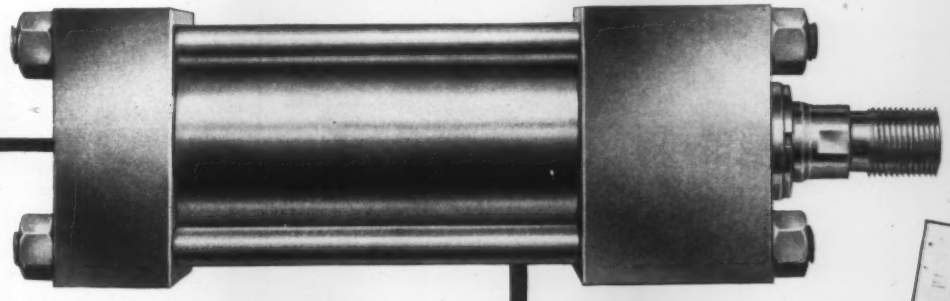

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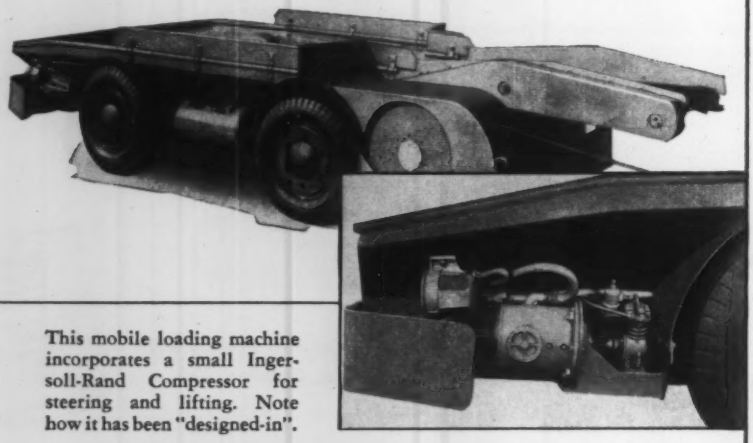

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Clarification of trade names and up-to-date formulations and manufacturing procedures, as well as properties of the materials, are included.

Creative Thinking. *By Charles S. Whiting; 168 pages, 5 by 7½ in., clothbound; published by and available from Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; $3.95 per copy.*

This book discusses the current outlook on creative thinking in an objective manner. A major portion of this book describes the operational techniques of creative thinking and discusses methods such as brainstorming, analytical, and mechanical techniques. Each technique is described and evaluated for strength and weakness, and suggestions for putting across new ideas are made.

The Structure of Steel. *By Edwin Gregory and Eric N. Simons; 176 pages, 5½ by 8¼ in., clothbound; published by Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y.; available from* MACHINE DESIGN, *$10.00 per copy postpaid.*

This book presents a nontechnical explanation of the metallurgical structure of various steels and steel alloys and discusses the effects that heat treatment, impurities, and metal-working processes have on material properties. Also included in the book are tables of properties for the various stainless steels

Association Publications

Quality Control in Action—Management Report 9. *116 pages, 6 by 9 in., paperbound; published by and available from American Management Association Inc., 1515 Broadway, New York 36, N. Y.; $3.00 per copy.*

Responsibilities and functions of successful quality control in its various phases are described. Methods on how to reduce cost of quality control and how to design quality products are included. Several spe-

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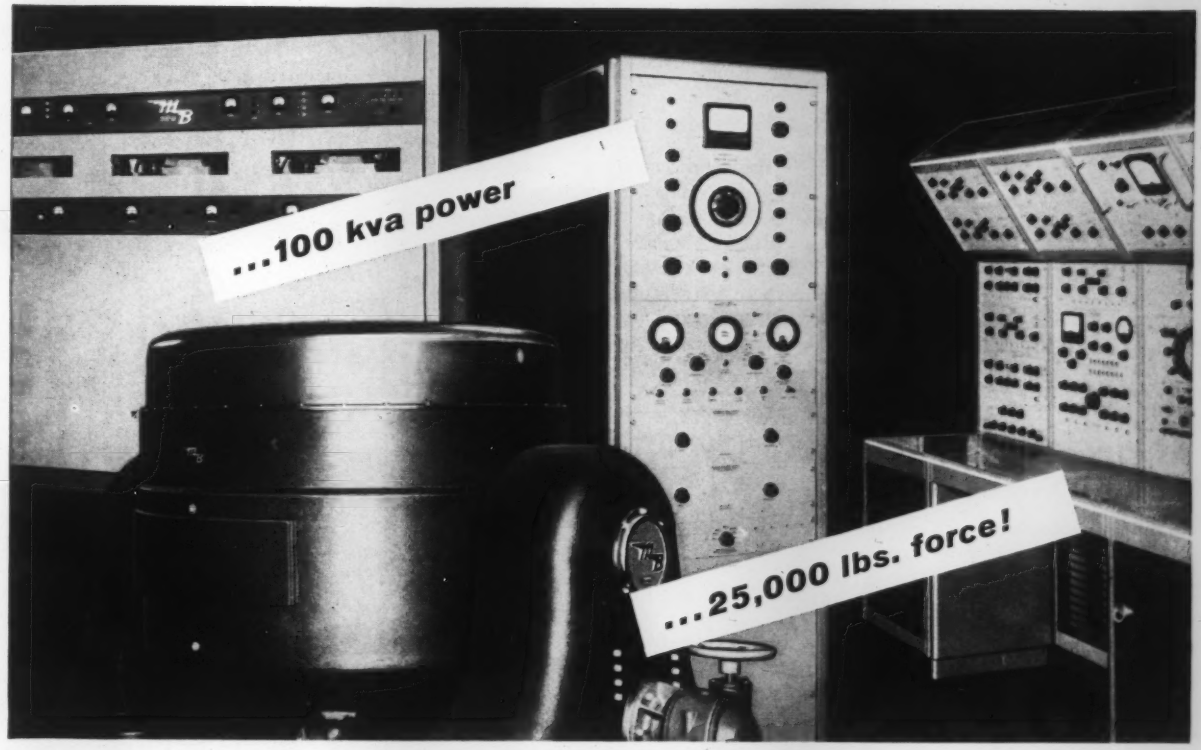

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Circle 580 on Page 19

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Plastic Sheet Forming — Management Report 12. *140 pages, 6 by 9 in., paperbound; published by and available from American Management Association Inc., 1515 Broadway, New York 36, N. Y.; $3.75 per copy.*

Information on plastic sheet forming; materials, techniques, and potentialities for the future. Materials, properties, characteristics, and applications of many plastics are given. Methods of vacuum forming, pressure forming, and airslip forming are covered.

Establishing a New-Product Program—Management Report 8. *125 pages, 6 by 9 in., paperbound; published by and available from American Management Association Inc., 1515 Broadway, New York 36, N. Y.; $3.00 per copy.*

Methods of planning, organizing, and carrying through a program of new-product planning are discussed in this report. Among the basic factors of product planning outlined in this book is the role that industrial designers play in such a program.

How to Plan Products That Sell—Management Report 13. *148 pages, 6 by 9 in., paperbound; published by and available from American Management Association Inc., 1515 Broadway, New York 36, N. Y.; $3.75 per copy.*

A description of how to organize profitable new-product programs. Basic aspects of programs discussed are roles that engineering plays in product development, staffing of the product-development program, and using outside research facilities in the program.

Manufacturers' Publications

Drawing For Good Reproduction. *By Arthur H. Rau; 33 pages, 8¼ by 11 in., paperbound; published by and available from National Association of Blueprint and Diazotype Coaters, 1757 K Street N. W., Washington 6, D. C.; $1.00 per copy.*

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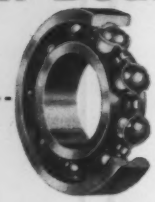

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Importance of good draftsmanship is stressed and techniques for improving reproduction suggested. Three sections cover essential elements of good reproducible documents and their preparation and care, useful life of reproducible documents, and reproduction processes and materials.

Government Publications

Hot Laboratory Equipment, *edited by Louis G. Stang, Jr., 429 pages, 8 by 10½ in., paperbound; published by the Atomic Energy Commission, available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.; $2.50 per copy.*

This book presents detailed descriptions and design data for facilities, equipment, and accessories for handling moderate to large amounts of radioactive materials. Included among the major classes of facilities are enclosures for radioactive operations, machine tools for working radioactive materials, and materials-handling equipment.

Temperature and Thermal-Stress Distributions in Some Structural Elements Heated at a Contsant Rate, TN 4306, *by William A. Brooks, Jr., 77 pages, 8 by 10½ in., paperbound; published by and available from National Aeronautic and Space Agency, 1512 H St., N. W., Washington 25, D. C.*

This technical note presents analytical solutions for the temperature and thermal-stress distributions in thick skins and structural elements such as angle, channel, T, and H-sections when heated at a constant rate. The results are presented in the form of charts involving dimensionless temperature, stress, and time parameters, and are applicable for different materials, heating rates, and absolute size of the section.

NASA Technical Series. *Each publication is 8 by 10½ in., paper bound; copies available from National Aeronautic and Space Agency, 1512 H St., N. W., Washington 25, D. D.*

The following reports are available:

TN 4284. Cumulative Fatigue Damage at Elevated Temperature. *By William K. Rey; 53 pages.*

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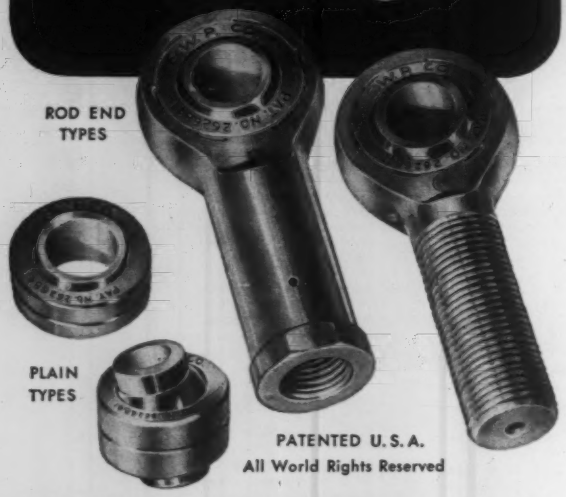

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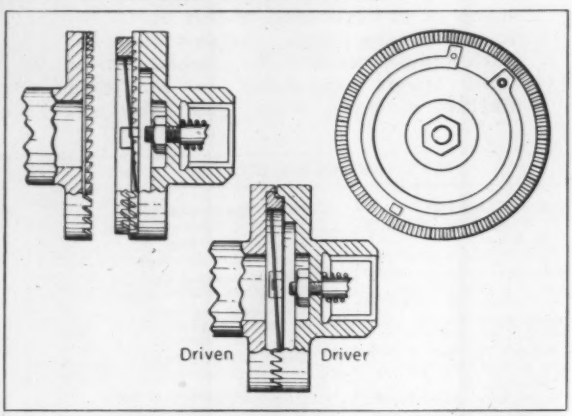
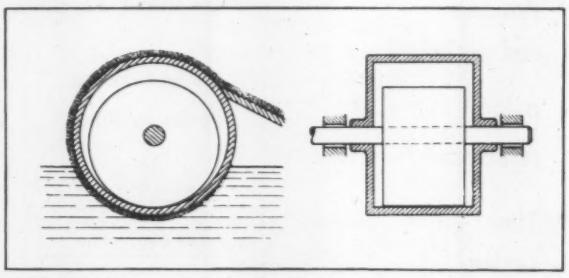


Between the main power-transmitting plates of a jaw clutch, an intermediate blocking ring prevents clashing of teeth during clutch engagement and ratcheting of teeth during disengagement. A circular small-deflection type torsion spring, connected at its ends to the driving jaw and the blocking ring, respectively, causes the blocking ring to float off the driving jaw when the clutch is disengaged. As the clutch is engaged, spring flexture permits teeth on the ring to mesh with mating teeth on the driving jaw. At the same time, friction faces of the ring and driven jaw engage to bring the latter member up to speed and thus cushion subsequent positive engagement of driving and driven jaws. *Patent 2,849,094 assigned to Bendix Aviation Corp., Teterboro, N. J., by John C. Vaiden.*

Rotary Magnetic Filter



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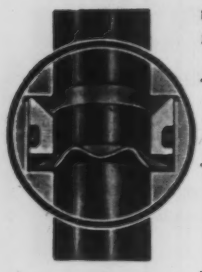

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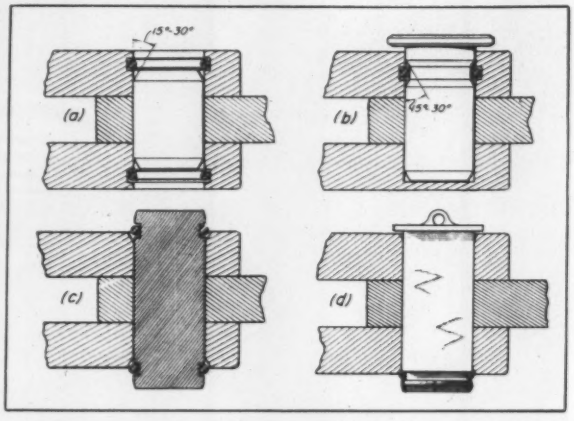
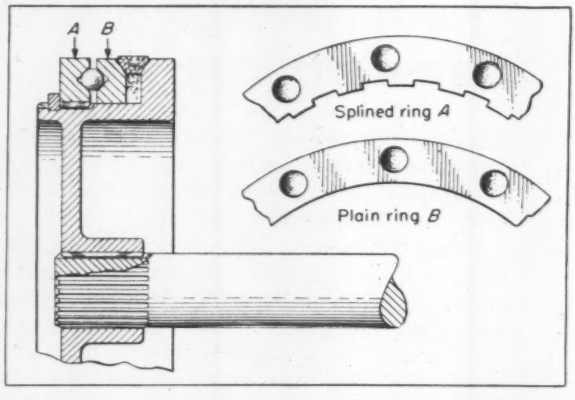


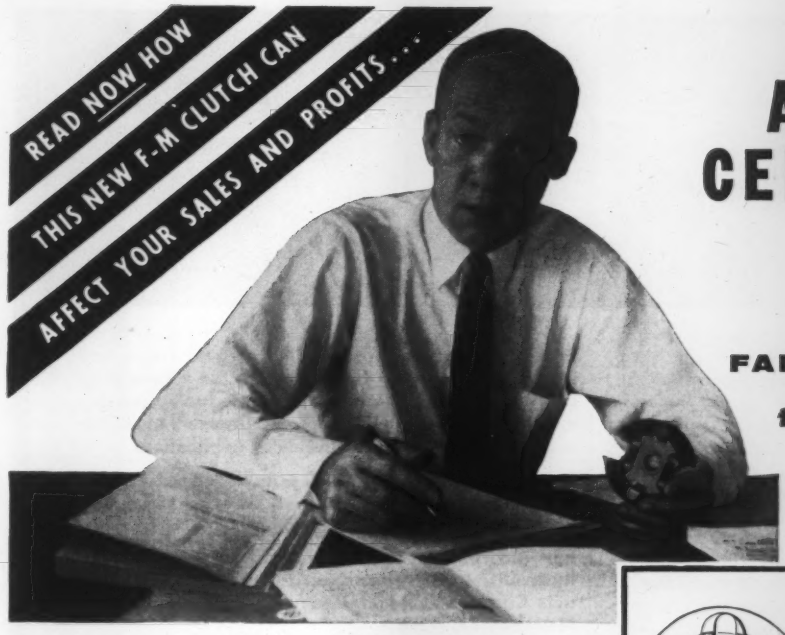
Ease of assembly and disassembly are claimed for linkage joints held together by pins retained by resilient O-rings. The rings seat in grooves which are rectangular in section and large enough in area to receive the entire section of a ring momentarily distorted to allow the pins to pass during assembly or disassembly. Lead angles on pins and holes facilitate these operations. Pins need not be round. The one in example *d* is square. *Patent* 2,847,238 *assigned to Esso Research and Engineering Co., Elizabeth, N. J., by Thomas J. Bolling.*

Self-Adjusting V-Belt Sheave



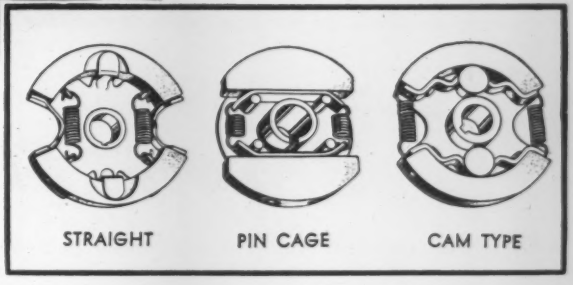
Increase in torque load on a sheave driving a V-belt causes a plain ring in the sheave flange to decrease the V-groove depth, tightening the belt and accommodating the higher torque. An inclined surface of the plain ring is one wall of the V-groove. Torque increase tends to rotate the plain ring relative to a similar ring fixed axially and splined to the flange. Due to this relative motion, balls held between the rings tend to climb out of matching conical recesses in both rings. This action decreases the groove depth. *Patent* 2,852,952 *assigned to General Motors Corp. by William S. Wolfram.*

Circle 588 on Page 19



A NEW AUTOMATIC CENTRIFUGAL CLUTCH

designed by FAIRBANKS-MORSE for the toughest usage you can name



Substantial cost savings for companies who can use it!

Here's an idea for engineers who want to reduce costs for profit improvement.

Simple design and high-volume production of these new clutches for motors and small gasoline engines mean substantial savings to you. And your quantity requirements make little difference in the cost.

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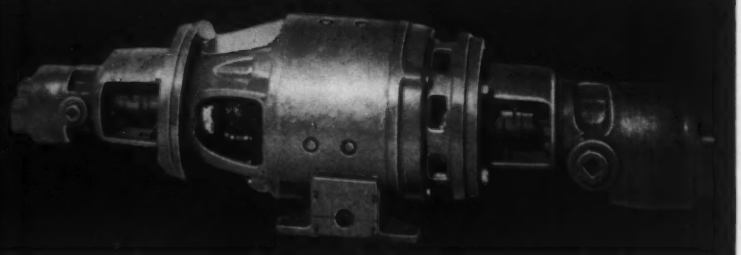
Circle 589 on Page 19

How stock pumps solve special problems



CASE HISTORY NO. F3954.

The photograph above illustrates Brown & Sharpe's solution of a turbine manufacturer's design problem. The heat absorbed by the turbine during normal operation makes necessary a cooling-off period of about 72 hours prior to inspection or repair of the rotor. To prevent bearing seizure and excessive shaft deflection during this period, the rotor must be turned slowly and the bearings cooled. Brown & Sharpe designed one economical, compact unit to do both jobs: two stock pumps were combined with a special motor to drive them both, one turning the rotor at 1 revolution per hour and the other providing cooling oil to the bearings.

Brown & Sharpe's complete line of gear, vane and centrifugal pumps — backed up by an engineering staff with the experience and knowledge to provide expert advice — has enabled our customers to realize substantial savings in thousands of applications.

For information about B&S pumps for fluid transfer please write to Brown & Sharpe Mfg. Co., Providence, R. I.

For information about pumps and valves for hydraulic applications, write to Double A Products Company, a subsidiary of Brown & Sharpe, Manchester, Mich.

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Circle 590 on Page 19

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FLOW indicating DEVICES

Tell when liquids are moving, if quality is right, and indicate flow.

Fig. 55A Flow Sight

Fig. 811 Flow Indicator

Fig. 816 Teleflow Indicator

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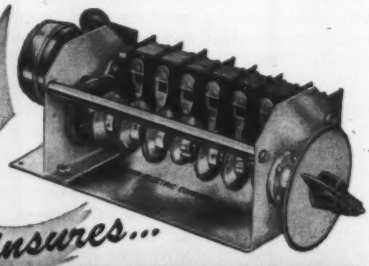

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Sound, practical design, quality components and precision-controlled assembly insure the long-lasting dependability of ZENITH Multi-Circuit Timers. They are specified as standard components in countless commercial and industrial applications, as well as laboratory equipment and home appliances.

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Circle 592 on Page 19

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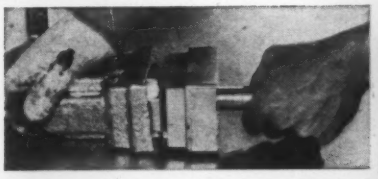

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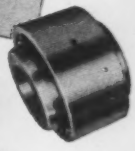
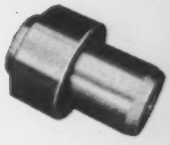
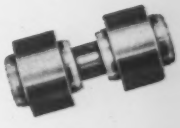
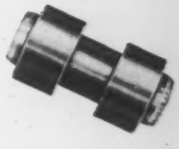
the NEW CATALOG C-5



Sier-Bath FLEXIBLE GEAR COUPLINGS







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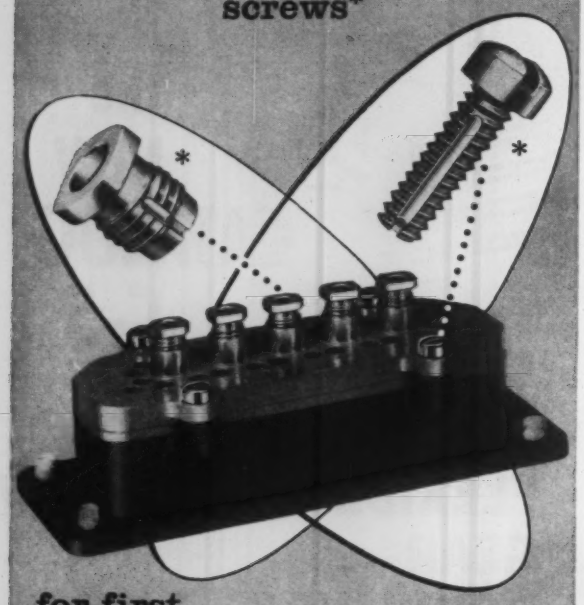

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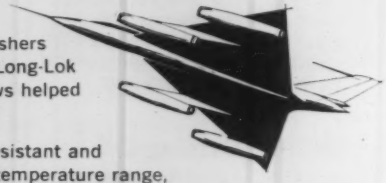

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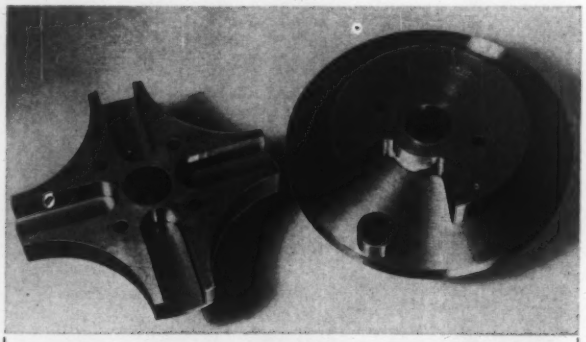

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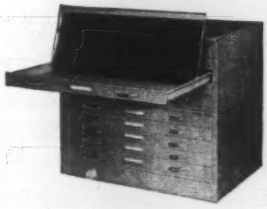

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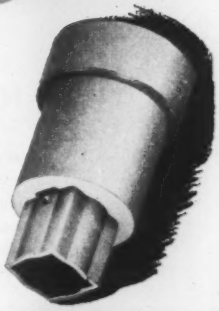
BRUSH HOLDERS



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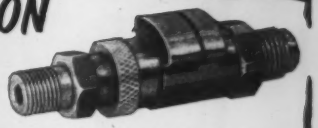

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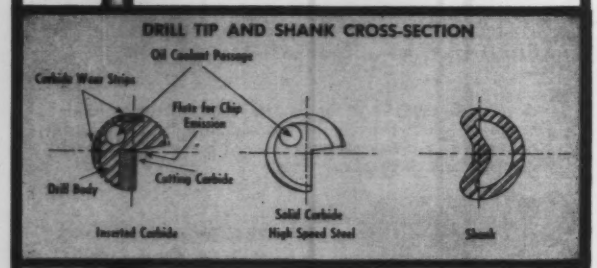

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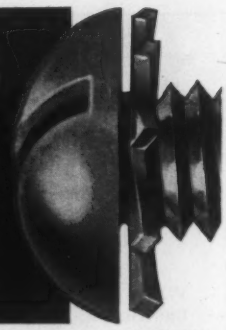

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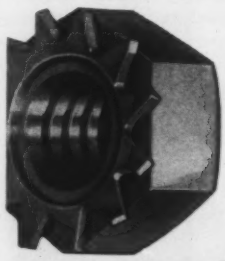

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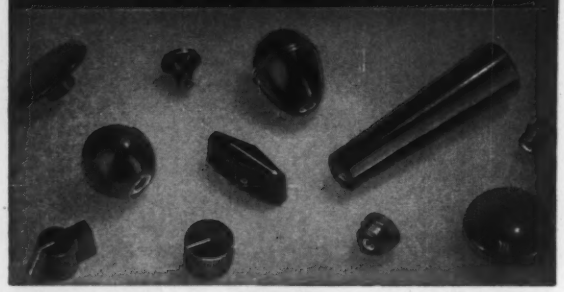
Circle 603 on Page 19

DIMCO-GRAY *Stock plastic* KNOBS...HANDLES



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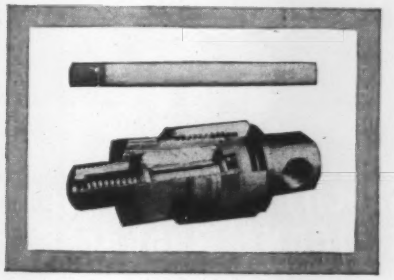

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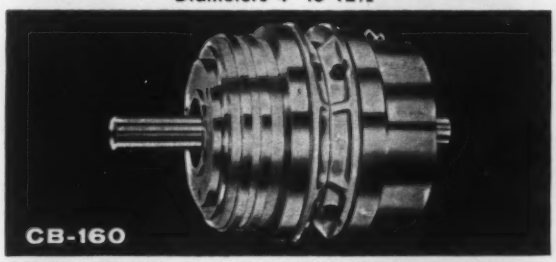
Diameters 4" to 12½"



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Representation in Key Industrial Areas

606-7

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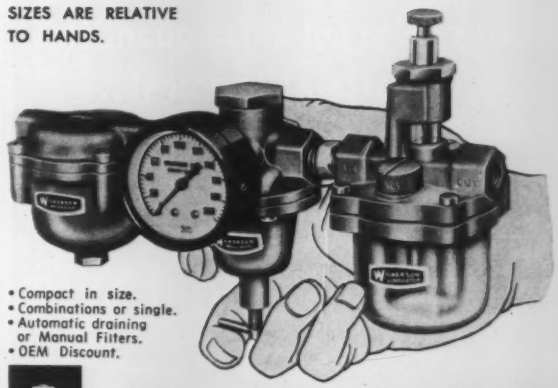
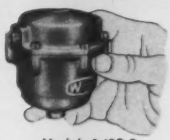


- Compact in size.
- Combinations or single.
- Automatic draining or Manual Filters.
- OEM Discount.

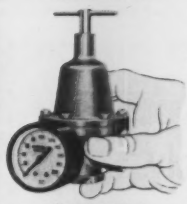
New WILKERSON MINIATURE Units *for* OEM Use



Model 1403-2

"WILK-O-MATIC" SEPARATOR

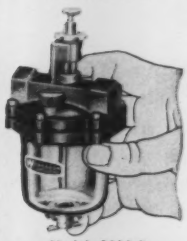
- Drains automatically each time air is used.
- Handles up to 18 CFM.
- Removes 5 micron particles.
- Maximum pressure 300 PSI.
- ¼" P.T. Larger sizes available.



Model 2000-2

"DIATROL" REGULATOR

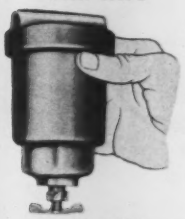
- Has 2 Gauge Holes.
- Tamper Proof, or Handy TEE Handle adjustment.
- ¼" P.T. Larger sizes available.
- No Chatter.
- Is self-relieving.
- Maximum pressure 250 PSI.
- Operating range 10 to 125 PSI.



Model 3000-2

"ATOMIZER" LUBRICATOR

- Handles up to 75 CFM.
- 3.5 ozs. bowl capacity.
- Metal or transparent bowl.
- Tamper Proof, or Handy Knob adjustment at same price.
- Site-Flo Gauge.
- ¼" P.T. Larger sizes available.
- Two large fill holes.
- Fill while air is on.
- Maximum pressure 250 PSI with metal bowl.
- Starts lubricating at ¾ CFM.



Model 1102-2

"FLO-KLEEN" FILTER

- Handles up to 18 CFM.
- Only 1.5 pressure drop at 100 PSI.
- Metal or transparent bowl.
- Large sump capacity.
- Removes 5 micron particles.
- Manual drain petcock.
- Maximum pressure 250 PSI with metal bowl.

Write for Our Catalog No. 157 describing these and other Air Line Products. Also ask for Our Combination Catalog No. 571.

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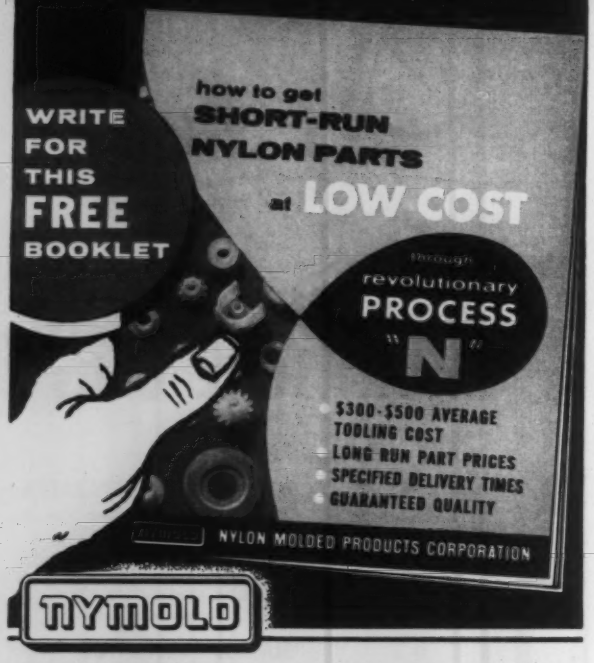
WILKERSON CORPORATION — **THE LEADING LINE OF AIR LINE PRODUCTS**

"Dedicated to keeping the NEW in pNEUmatics"

1646 W. Girard, Englewood, Colorado
Use "Dep't ID" for International Division

Circle 607 on Page 19

Learn how to get small quantities of nylon parts at low cost...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how to get SHORT-RUN NYLON PARTS at LOW COST
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LONG RUN PART PRICES
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GUARANTEED QUALITY
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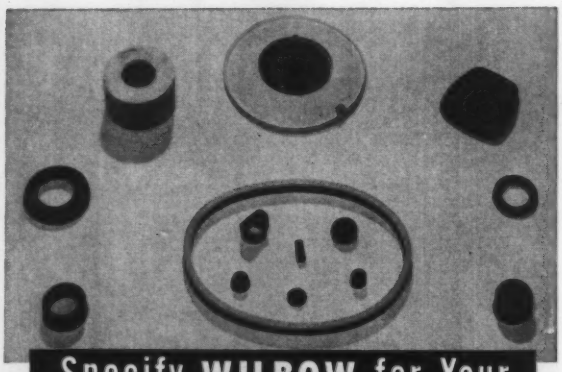
NYMOLD

NYLON MOLDED PRODUCTS CORP., GARRETTSVILLE 8, OHIO

Circle 608 on Page 19



Specify WILBOW for Your SILICONE Rubber Parts

■ WILBOW silicone rubber parts have many desirable characteristics in addition to excellent stability under temperature extremes (−125° to +600° F). Silicone may be the answer to your problem if your parts require low compression-set, good dielectric properties, resistance to ageing, sunlight or ozone, exceptional release from sticking or other characteristics not commonly found in natural rubber or other synthetics.

We are well experienced in producing silicone parts by techniques such as molding, extruding, calendering, bonding or punching from sheet. Let us know of your requirements.

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wilbow

The WILLIAMS-BOWMAN RUBBER Co.

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Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

Circle 609 on Page 19

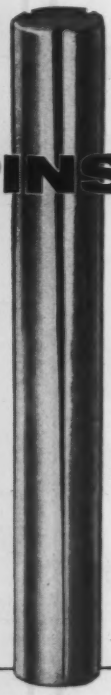
For Fast Assembly...

GILLEN GROOVE PINS

No Reaming

Drill the hole...

Insert the pin



Fast... Secure

Saves Time and Money

3 grooves compress and reform to diameter of hole for tight positive fit . . . no tapping, no threading, no reaming.

Six types, for *many applications*, variety of lengths and diameters, all metals.

Write for information. Ask for samples.

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Keying and Pinning Devices

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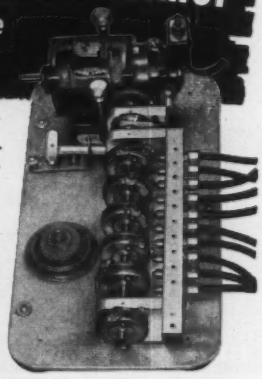
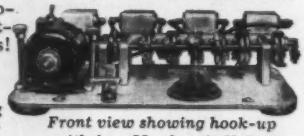
Electro-Pneumatic Timer

Controls Intricate Work Cycles...



This simple but astonishingly ingenious unit distributes air pressure to air-operated cylinders, presses, hammers, work feeders, clamping fixtures, chip blowers, work ejectors . . . each independent as to start, duration and end of cycle. Simply connect up 6, 12 or more cylinders in numerous sequences from 2½ to 33½ seconds. *You need this inexpensive* Mead Electro-Pneumatic Timer for cost-saving automation jobs!

No. 6 Electro-Pneumatic Timer



Front view showing hook-up with four Meadmatic Valves

Write Factory or Nearest Mead Representative For Bulletin 0000

Write for our cost-saving catalog. Or let the Mead Man show you.

(See Volume III Thomas' Register for nearest distributor's address, phone number.)

MEAD SPECIALTIES COMPANY

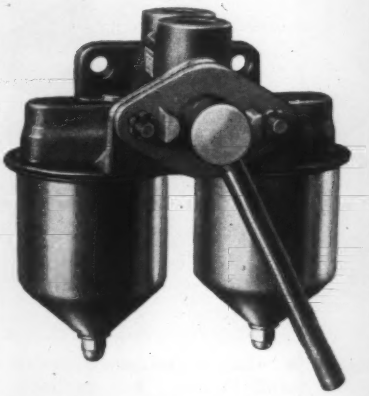
4114 N. Knox Ave., Dept. MD-118, Chicago 41, Ill

PATHFINDER IN AIR POWER AUTOMATION

Circle 611 on Page 19

Circle 610 on Page 19

CLEANABLE DUPLEX FILTER
for continuous flow operation

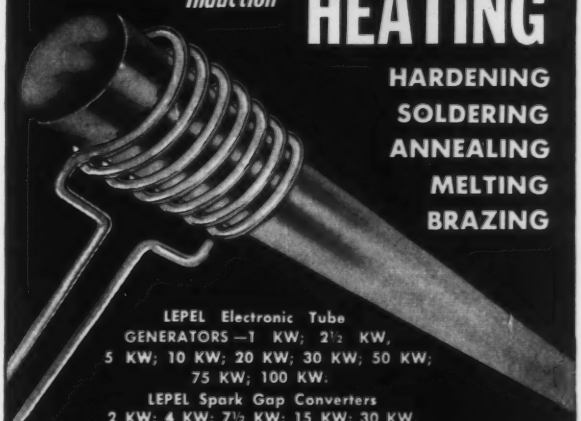


Continuous liquid flow with extremely fine particle filtration is achieved with Air-Maze cleanable Duplex Liquid Filters. By paralleling two filters through a common header containing a diverter valve, one filter unit handles the full liquid flow while the second filter is being cleaned. Filter media is specially processed metal screen of bronze, monel or stainless, over perforated tube and assembled in a container. Screen openings are precisely controlled to provide various degrees of filtration. Standard Duplex Filters are available for pipe sizes down to ⅛" and in capacities from ½ gpm to 720 gpm at pressures up to 100 psi. Write for Bulletin LFC-556. **AIR-MAZE CORPORATION**, Cleveland 28, O. Dept. MD-11.

Circle 612 on Page 19

Lepel

HIGH FREQUENCY *Induction* HEATING



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LEPEL Electronic Tube GENERATORS—1 KW; 2½ KW, 5 KW; 10 KW; 20 KW; 30 KW; 50 KW; 75 KW; 100 KW.

LEPEL Spark Gap Converters 2 KW; 4 KW; 7½ KW; 15 KW; 30 KW.

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Circle 613 on Page 19

RELIABILITY *must* START ON THE GROUND

Missile launching equipment manufacturers must be positive of every component in their vital equipment. For this reason, Air-Marine blowers are specified equipment in many of the launching beds built today. The blower shown here is currently being used in the Army's NIKE Hercules Program. Interested manufacturers are urged to look into the proven reliability of Air-Marine's complete selection of sub-fractional H.P. Motors, Blowers and Fans.

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AMITYVILLE, NEW YORK
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AIR-MARINE MOTORS, INC.

Circle 614 on Page 19

3½ times as many studs
by cold heading

Although this finned collar stud served its function well, it proved too expensive to machine. Progressive made it by cold heading, in just three steps: head, flatten, and thread. Instead of machining it from $1\frac{1}{16}$" bar, we cold headed it from .326" diameter wire—without waste. Over 3½ times as many studs from the same amount of metal.

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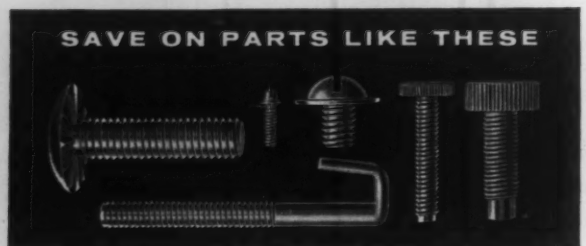
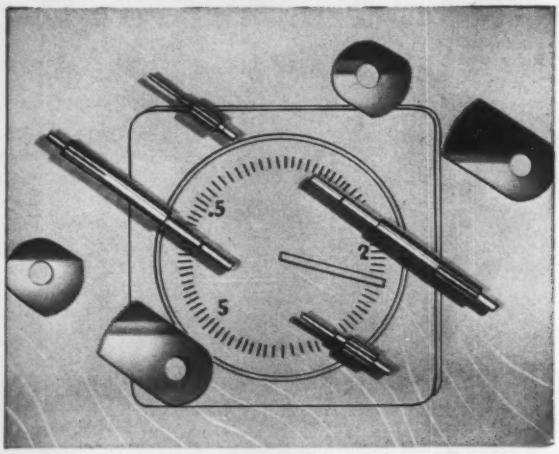
THE PROGRESSIVE MFG. CO.
Division of The Torrington Company
52 Norwood St., Torrington, Connecticut



AMONG OPERATIONS PERFORMED BY PROGRESSIVE are heading and extruding simultaneously; flattening; piercing; drilling; bending; pointing; fluted or diamond knurling; trimming; turning tenons, shoulders or recesses; struck or sawed slotting; notching.

20 TO 200 D.P.

SEND YOUR PRINTS FOR QUOTATION



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THE *Finest* IN GEARS

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Circle 616 on Page 19

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Perhaps one of our advertisers in this issue of MACHINE DESIGN has the solution to your dilemma. We'll be willing to bet that this issue contains information that is essential to answering your problem.

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Why not do it right now?

USE THE YELLOW CARD ON PAGE 19.

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EASTMAN HIGH PRESSURE LEADERS

All available in sizes from ¼" thru 2"
375—5000 PSI working pressures.

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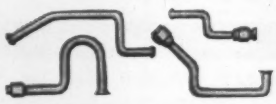
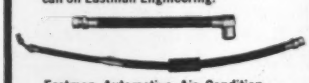


Bent Tubing designed to your specifications. Submit your blueprints or call on Eastman Engineering.



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Let EASTMAN recommend the best assembly . . . for the best performance . . . at the lowest cost.

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Eastman MANUFACTURING COMPANY
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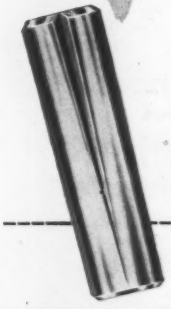
Circle 617 on Page 19

have you checked

DRIV-LOK PIN advantages?



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2. **Stronger, safer, solid body**
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DRIV-LOK Pins are effecting great economies and product improvement in applications of every type. Easy to install — just drill the hole and press or drive them in. The job is done — no reaming, no expensive hole preparation. Available in carbon steel in 8 standard types; also a wide variety of special materials. Write us, describing your fastening requirements. Catalog and samples sent without obligation.

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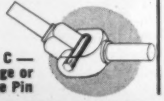
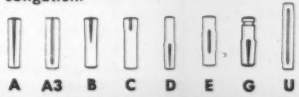


Type C — Linkage or Hinge Pin



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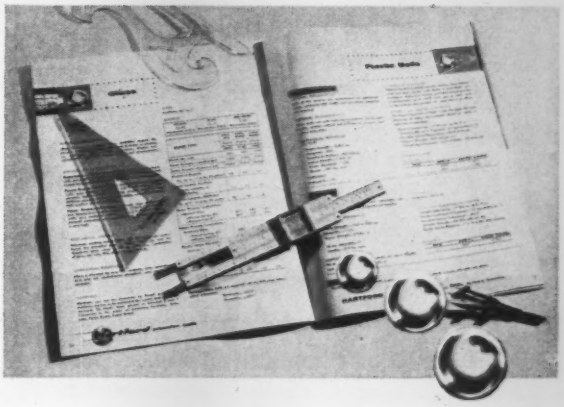
715 Park Avenue • Sycamore, Illinois

Circle 618 on Page 19

Every design engineer should have this technical guide to...

Precision Balls



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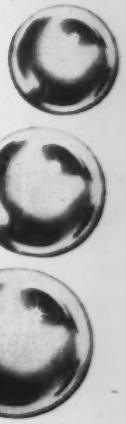

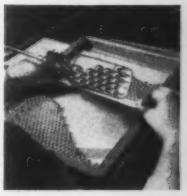

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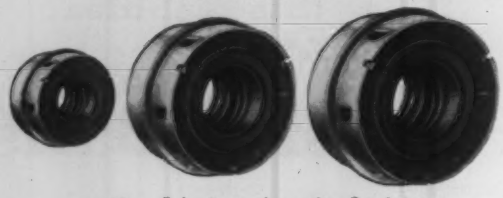
Circle 619 on Page 19

NEW HY DUTY J-2 SEALS

FOR THOSE APPLICATIONS THAT REQUIRE THE BEST



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of exceptional durability—
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The economy is found in its long life and dependability.

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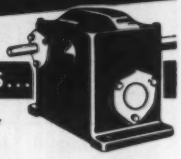
Circle 620 on Page 19

Abart Specializes in a complete line of Speed Reducers and Gears



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Circle 621 on Page 19

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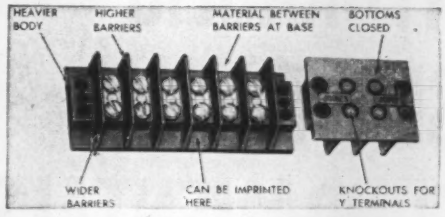

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Jones
HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24, ILLINOIS
SUBSIDIARY OF UNITED-CARR FASTENER CORP.

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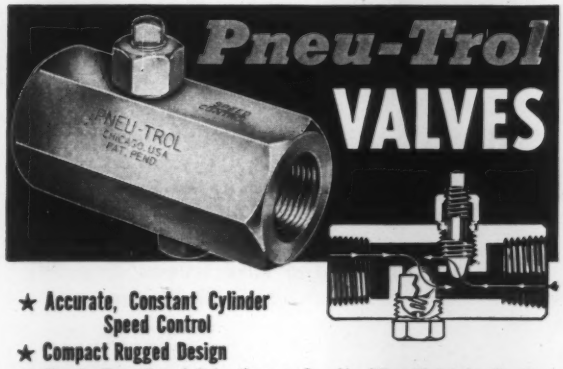
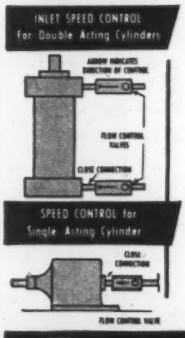
Pneu-Trol VALVES



★ Accurate, Constant Cylinder Speed Control
★ Compact Rugged Design
★ Simple, Easy Speed Selection ★ For Air, Oil or Water Applications



Pneu-Trol Speed Control Valves are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

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Circle 623 on Page 19

HERE'S THE WAY TO CUT THOSE ★!*!d× PRODUCTION COSTS

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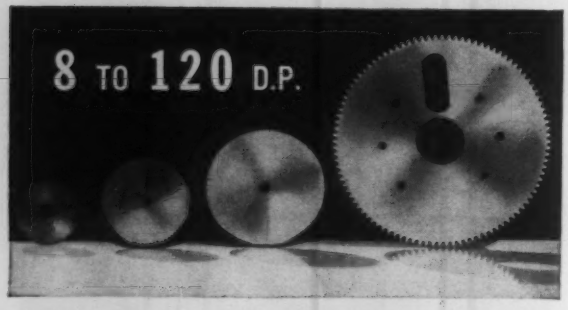

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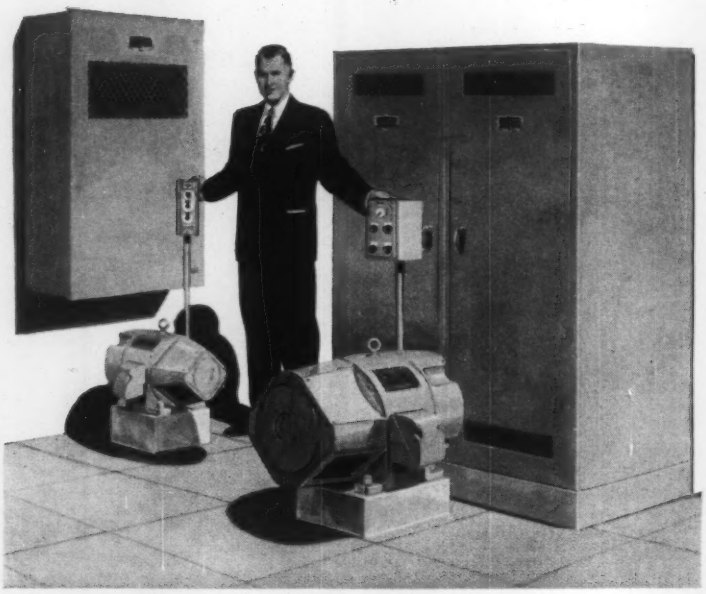

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